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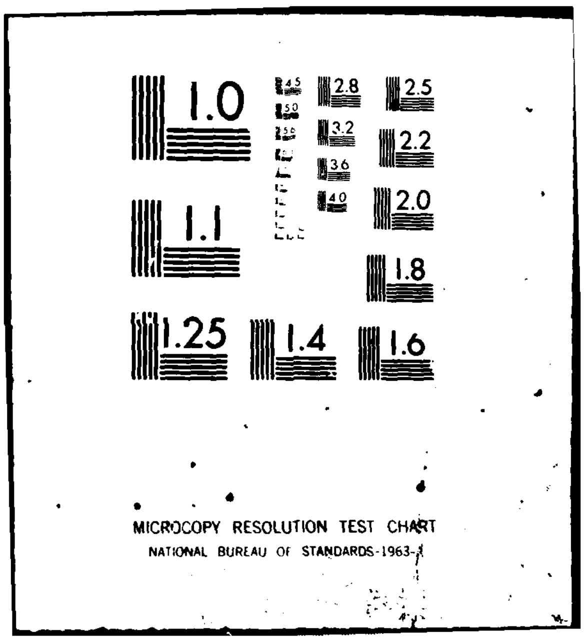
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16. Abstract

Since September 1978 side-looking airborne radar (SLAR) detection data has been gathered in conjunction with visual detection experiments conducted by the U.S.C.G. R&D Center. These are the first in a series of experiments designed to improve search planning guidance contained in the National Search and Rescue Manual.

HC-130 aircraft, equipped with either the Airborne Oil Surveillance System (AOSS) or SLAR/radar image processor (SLAR/RIP) configuration of the AN/APS-94D SLAR, conducted controlled searches for life rafts, small boats, and 41- to 95-foot Coast Guard vessels in Block Island Sound or open ocean.

Through the use of a microwave ranging system and SLAR data, the positions of searchers and targets were accurately reconstructed to facilitate the verification of detections on SLAR films or video tape. These data were used to evaluate the effects of environmental and controllable parameters on SLAR detection of the various target types.

While the size of the data base did not permit conclusive, quantitative assessment of the effect which each parameter had on SLAR detection performance, general trends in system performance were identified. Of the 11 parameters which were investigated, preliminary indications are that wind speed, image background, sea state, precipitation, altitude, antenna polarization, target size/composition, and lateral range all may significantly influence SLAR detection of search and rescue targets. Further data collection and analysis is planned to quantify the affects of these and any other significant parameters on SLAR performance.

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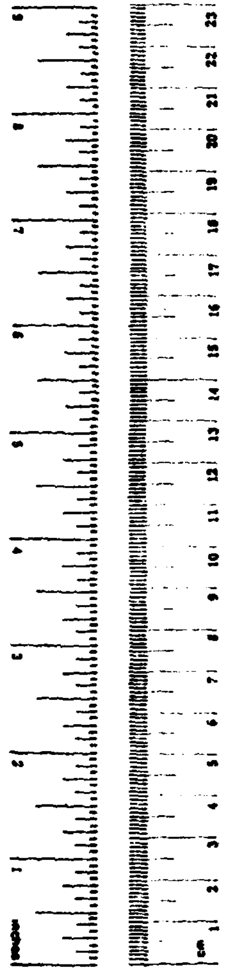
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

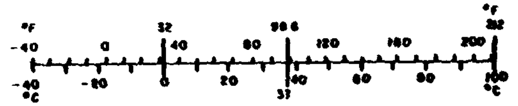
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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INTRODUCTION

1. Purpose of Report

Analysis results of three side-looking airborne radar (SLAR) detection experiments conducted by the Coast Guard Research and Development Center are presented in this report. A preliminary evaluation of SLAR effectiveness as a sensor in search and rescue (SAR) operations involving life rafts, 13- to 21-foot boats, and 41- to 95-foot boats is made.

2. Background

While SLAR has been used aboard HC-130B aircraft primarily for airborne surveillance of oil spills and icebergs, it has potential for use as a SAR sensor because of its superior resolution and detection range compared to standard search radars, and its image-processing capabilities. In situations where other methods of search are ineffective or impossible, SLAR, which is not as susceptible to adverse environmental conditions, may provide a means of detecting SAR targets. SLAR also has the ability to search very large areas in a short period of time, making it a valuable sensor in time-critical situations.

To evaluate the effectiveness of SLAR for the Coast Guard SAR mission, SLAR searches were conducted in conjunction with two visual detection experiments in Block Island Sound during the fall of 1978 and fall of 1979. In addition, SLAR searches were conducted on three days during a January 1979 leeway drift experiment off the Florida coast.

Preliminary analysis of the collected data has been conducted to determine the influence which certain environment-related parameters and controllable parameters have on SLAR detection of the target types described above. Parameters which were investigated are:

Environment-Related	Controllable
Wind speed	Target size and composition
Swell height	Antenna polarization
Relative humidity	Gain
Precipitation	Altitude
Image background	Lateral range
Visibility	

3. Description of SLAR

The SLAR units which were tested during the experiments are the Airborne Oil Surveillance System (AOSS) and SLAR/Radar Image Processor (RIP) system. Both of these units are versions of the AN/APS-94D real aperture radar system interfaced with an onboard computer system, television monitors, and photographic and videotape recorders.

The AOSS SLAR employs two permanent side-mounted antennae: an 8-foot vertically polarized antenna on the right and a 16-foot horizontally polarized antenna on the left fuselage of the CG 1347 HC-130B aircraft. The vertically polarized antenna has been found to be effective in detecting changes in sea-return (such as those caused by oil spills))), while the horizontally polarized antenna has proven more efficient at detecting "hard" targets such as ships and icebergs. The SLAR/RIP system employs a single, 16-foot long, horizontally polarized antenna mounted below the tail of the CG 1351 HC-130B aircraft, and is equipped with a RIP which performs sophisticated image analysis and storage/retrieval functions.

The SLAR computer compensates for signal attenuation, aircraft speed and attitude, and annotates an advancing video display with information including date, time, position, speed, altitude, and range marks. Film records of the video displays can be made in-flight for post-experiment analysis of the SLAR image. All data in this report were gathered for post-experiment analysis.

RESULTS

While limitations of the data base did not permit a rigorous, quantitative investigation of every parameter, a preliminary assessment of their influence on SLAR performance was made. Parameters which were found to influence SLAR detection of SAR targets during these experiments include:

Environment-Related	Controllable
Wind speed	Target size and composition
Image background	Antenna polarization
Precipitation	Altitude
	Lateral range

CONCLUSIONS

1. Wind Speed

Wind speed appears to be the most significant environmental parameter influencing SLAR detection performance. SLAR detection of small targets (life rafts and 16-foot boats) degrades dramatically at high (> 20 knots) wind speed due to increased sea state.

2. Image Background

Image background varies with wind speed (sea state), precipitation, gain selection, and altitude. Optimum combinations of these parameters should be determined for conducting SLAR searches.

3. Precipitation

Presence of precipitation, while not encountered often in this data base, does appear to contribute to poor image quality making resolution of small targets difficult.

4. Target Size and Composition

This parameter is by far the most significant in determining SLAR detection performance. Larger targets (41- to 95-feet long) were detected on nearly every opportunity. Detection of smaller boats is influenced by the amount of reflective material they contain. Small, corner-type radar reflectors do not appear to enhance the detectability of life rafts substantially. Other reflective devices should be tested.

5. Antenna Polarization

Use of a horizontally polarized SLAR antenna results in better detection performance with hard targets than use of a vertically polarized antenna. This conclusion is consistent with previous findings of others.

6. Altitude

Optimum SLAR search altitudes may exist for various target types. This parameter should be investigated systematically to provide more conclusive informat.on.

7. Lateral Range

A blind zone directly beneath the aircraft exists where no detections are possible. The blind zone is partially altitude-dependent due to the antenna pattern. However, this blind zone may extend out to 2 nm even at low altitudes for small targets because of excess sea return. A maximum detection range of about 18 nm was found to exist for SLAR/RIP detection of small targets, but no maximum range was determined for other data bases.

RECOMMENDATIONS

Additional experiments will be conducted in the near future as part of the Project Master Plan to achieve the following goals:

a. Collect sufficient data to quantify SLAR system performance under a variety of environmental conditions.

b. Define optimum values of controllable SLAR operating parameters for a variety of target types and environmental conditions.

c. Develop guidelines which will enable search planners to make the most efficient use of SLAR in SAR operations.

d. Develop appropriate measures of performance to enable cumulative probability of detection (POD) to be predicted for SLAR searches.

e. Evaluate combined visual and SLAR search performance.

Chapter 1
INTRODUCTION

1.1 SCOPE

This report presents empirical results of side-looking airborne radar (SLAR) detection experiments and provides a preliminary assessment of its effectiveness as an aid to search and rescue (SAR) operations. These experiments were conducted by the United States Coast Guard Research and Development (R&D) Center in conjunction with visual detection and leeway drift experiments during fall 1978 and during winter and fall 1979. Targets included small boats, life rafts, and 41- to 95-foot boats.

These Coast Guard SLAR systems were not specifically designed to detect small SAR targets, but rather for ice and/or oil spill surveillance. The superiority in resolution which SLAR enjoys over standard search radar makes an evaluation of its effectiveness as a sensor for SAR operations appropriate. No alternative detection method may be available in poor visibility, nighttime or limited-resource situations. The environmental conditions and other parameters which affect SLAR performance in detecting small targets are evaluated in this report.

1.2 BACKGROUND

1.2.1 Description of SLAR

The SLAR system incorporates an AN/APS-94D radar combined with an onboard computer system, video monitors, and photographic recorders. The radar uses long antennae mounted on the sides or below the tail of the aircraft. SLAR operates by microwave echo ranging similar to conventional radar; however, SLAR uses the forward motion of the aircraft rather than a rotating antenna to provide an advancing display. This technique, combined with the long antennae, allows for superior resolution.

The SLAR system performs functions such as aircraft yaw correc range conversions. Enhanced signals are displayed in a rolling-map format on video monitors and photographic film which is automatically processed on-board. The rate of advance for both video and film is correlated to aircraft ground speed and is controlled by inputs from the aircraft's navigation system. Displayed with the SLAR image are range reference marks and Airborne Data Annotation System (ADAS) data blocks showing date, time, position, altitude, speed, heading, roll, pitch, and yaw. The SLAR/RIP system photographic film does not have the ADAS. In addition, a target cursor marks and calculates target position on the SLAR video display (in this event, the target location is included in the ADAS block). All this information is transmitted directly from the inertial navigation system (INS) and cockpit instruments of the aircraft to the onboard computer.

Two Coast Guard HC-130 aircraft are configured for SLAR installation but each has a different antenna system. CG 1347, based at Elizabeth City, NC, is the Airborne Oil Surveillance System (AOSS) aircraft which has a SLAR system with the antennae mounted on the fuselage. CG 1351, based at Clearwater, FL, is configured for SLAR or SLAR with Radar Image Processor (RIP) and has a single, tail-mounted antenna. The two SLAR systems have different signal strength, antenna pattern, and polarization resulting in potentially different system performance. The frequency of the radars is X-band and tunable between 9.10 and 9.40 GHz.

a. AOSS SLAR. The Coast Guard AOSS (Reference 1) is a multi-mission airborne ocean surveillance system designed to provide 24-hour, adverse weather surveillance for SAR, the enforcement of laws and treaties (ELT), and marine environmental protection (MEP). SLAR is only one of several electronic sensors which comprise the total AOSS system. The AOSS unit uses two real-aperture radar (RAR) antennae: an 8-foot long, vertically polarized antenna mounted on the right side of the aircraft and a 16-foot long, horizontally polarized antenna mounted on the left side. Previous exercises (Reference 2) have shown that the horizontally polarized antenna provides better

resolution of hard targets such as ships and icebergs, while the vertically polarized antenna is better suited to oil-slick detection because it enhances surface-structure return from the sea.

The SLAR AN/APS-94D radar provides coverage from 45 degrees with the vertical to up above the horizon. Output power is 45 Kw peak, but some signal strength is lost in the long, complicated wave guide. The effective surveillance capability is 27 nm (50 km) to either side of the aircraft.

A real-time black and white or color video monitor or a 9.5-inch film record displays the SLAR image in rolling-map format. For higher resolution the display swath-width can be halved to give real time and post-experiment analysis coverage of 13.5 nm (25 km) to either side of the aircraft. This smaller display scale was used during the detection experiments of fall 1978 and winter 1979.

b. SLAR/RIP. During the fall 1979 experiment, CG 1351 was outfitted with a SLAR/RIP system (Reference 3). SLAR/RIP also uses the AN/APS-94D radar but with a 16-foot long, horizontally polarized antenna and a shorter, more simplified wave guide. Output power is 45 Kw peak. This system can conduct surveillance as far as 55 nm (100 km) to either side of the aircraft. SLAR/RIP has three available mapping swaths: 13.5 nm (25 km), 27 nm (50 km), or 55 nm (100 km) to each side of the aircraft; the swaths can be offset in 5.5 nm (10 km) increments by the operator. Magnetic tape is the primary means of recording data with the SLAR/RIP system, but SLAR film recording is also available.

To enhance detection and attempt target recognition, the RIP has become a useful interactive system. The radar image is presented in a real-time, moving window display on a pair of essentially standard color video monitors driven by a solid-state refresh memory. Two cursors are available: one for operator use and the other to automatically locate targets. RIP provides geometric corrections (for

drift angle, aircraft speed, and slant range), amplitude calibrations (for antenna pattern, aircraft roll, transmitter power and receiver gain), dynamic target threshold calculations, perceptive target description, target position, and target tracking.

The SLAR/RIP system is owned and operated by the NASA-Lewis Research Facility, Cleveland, Ohio and was on loan to the Coast Guard for these experiments.

Although the two SLAR systems tested are distinctly different, the operating ranges and navigational capabilities of the two aircraft are similar. Unfortunately, it was not possible to conduct their performance tests simultaneously during these experiments to provide a direct comparison.

1.2.2 Blind Zone, Shadowing Effect, and Resolution

Because of the angle through which the SLAR microwave signal is transmitted, a *blind zone* extends to each side of the flight path a distance roughly equal to the aircraft's altitude (see Figure 1-1). Although it is beneficial to fly at low altitudes to reduce the blind zone, low altitudes increase the amount of shadowing produced by taller objects and the amount of sea return near the boundary of the blind zone.

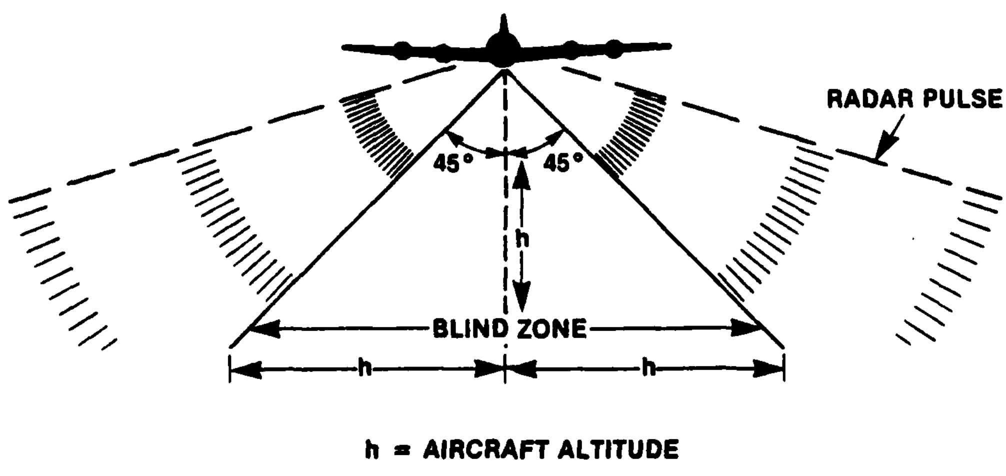


Figure 1-1. Blind Zone in SLAR Coverage

The geometry involved with the shadowing effect (Figure 1-2) yields an equation for calculating the length of the shadow zone which an obstructing object will create for a target of given size. This equation is:

$$X = (h-t)G/(H-h)$$

where

X = length of shadow zone created by obstructing object
G = obstructing object range from flight path
h = obstructing object height
t = target height
H = aircraft altitude

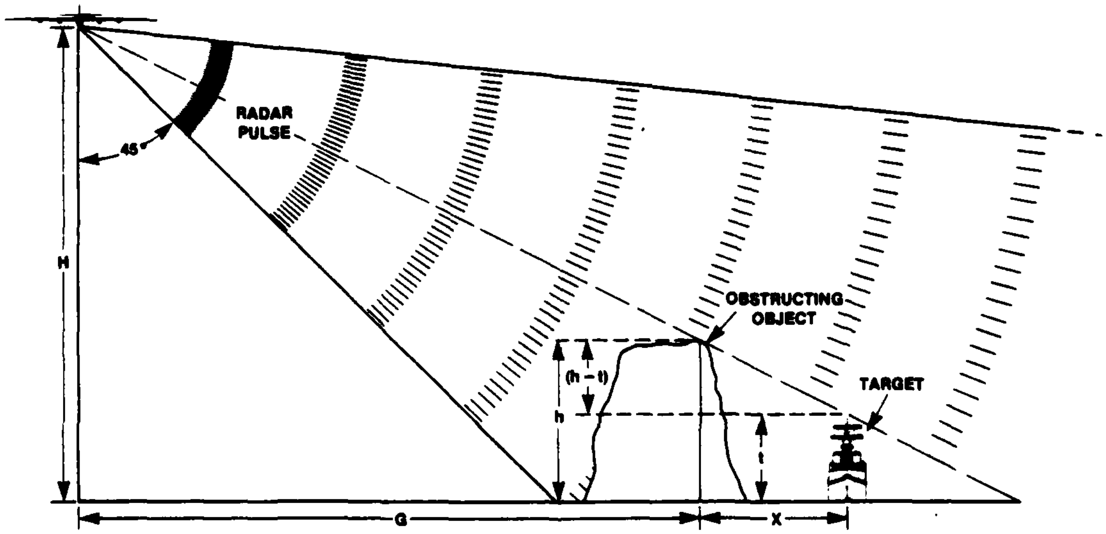


Figure 1-2. Geometry Involved with Shadowing Effect

For example, at an aircraft search altitude of 5,000 feet, a two-foot high boat in four-foot seas is shadowed for 2.4 feet at a 1 nm range and shadowed for 60 feet at a 25 nm range.

Resolution (detection and differentiation between individual targets provided one does not shadow the other) in the across-track direction is dependent on the microwave pulse length and therefore remains constant at 30 meters as range increases. Resolution in the along-track direction is dependent on beamwidth and therefore deteriorates at a rate of 9 meters per km from an initial resolution of 9 meters at 1 km. (References 1 and 3)

1.2.3 SLAR Performance in Other Scenarios

In the past, SLAR systems have been utilized for iceberg identification, ice floe mapping, and oil spill detection.

One intended use of SLAR equipment in iceberg identification has been to produce truth data to compare with SEASAT-A synthetic aperture radar data (Reference 4). SLAR is well suited for this purpose because of its weather-penetrating capabilities as well as its near real-time display and output.

The SLAR/RIP system was used to map ice floes around Pt Barrow, Alaska in late summer of 1976 (Reference 5). Flying at an altitude of 11,000 feet and an average ground speed of 265 knots, the SLAR aircraft successfully mapped swaths of ocean up to 100 km wide in a variety of weather conditions. The high resolution of SLAR made possible identification of oil rigs, tugs, barges, islands, and ice in periods of varying visibility. When the USCG ice breaker GLACIER was unable to deploy helicopters for visual ice observations, SLAR aircraft were able to provide the necessary ice floe maps.

The AOSS SLAR aircraft used for oil spill detection and mapping has detected spills out to a range of 13 nm from the flight path. The vertically polarized antenna performed best for detecting oil spills. Since SLAR distinguishes oil's smoothing effect on the water, it was most effective at wind speeds greater than five knots. In a seven-month period from April through

October 1977, the AOSS SLAR aircraft logged a total of 143 flight track hours, imaging an average of 5875 nm^2/hour resulting in a total of over 840,000 nm^2 imaged (Reference 2). Most missions were flown at altitudes between 2500 and 5000 feet. During these operations, the horizontally polarized antenna performed better than the vertically polarized antenna at detecting hard objects such as icebergs.

In all of these exercises, the SLAR displayed greater resolution capabilities than conventional radar systems. However, SLAR resolution does deteriorate as range increases and its ability to detect small targets or discern small targets from large waves in a SAR operation is still to be determined. Effects of inclement weather on SLAR performance must be evaluated along with the development of appropriate measures of effectiveness for SLAR in SAR operations. SLAR possesses some useful and unique capabilities; whether these may be suited to SAR applications is the subject of this report.

1.3 MEASURES OF SEARCH PERFORMANCE

The primary performance measure currently used by SAR mission coordinators to plan searches is sweep width (W). Sweep width is a single number representation of a more complex lateral range/target detection probability relationship. Mathematically,

$$\text{Sweep Width } (W) = \int_{-\infty}^{+\infty} P(x)\,dx,$$

where

x = lateral range (see Figure 1-3) and
$P(x)$ = probability of detection at lateral range x.

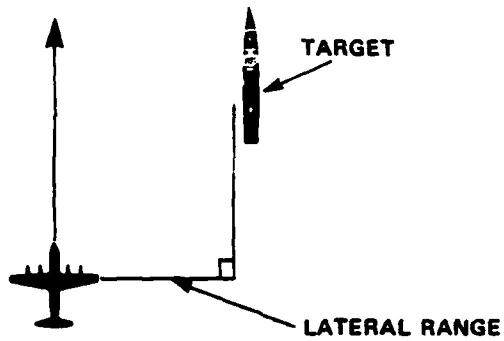
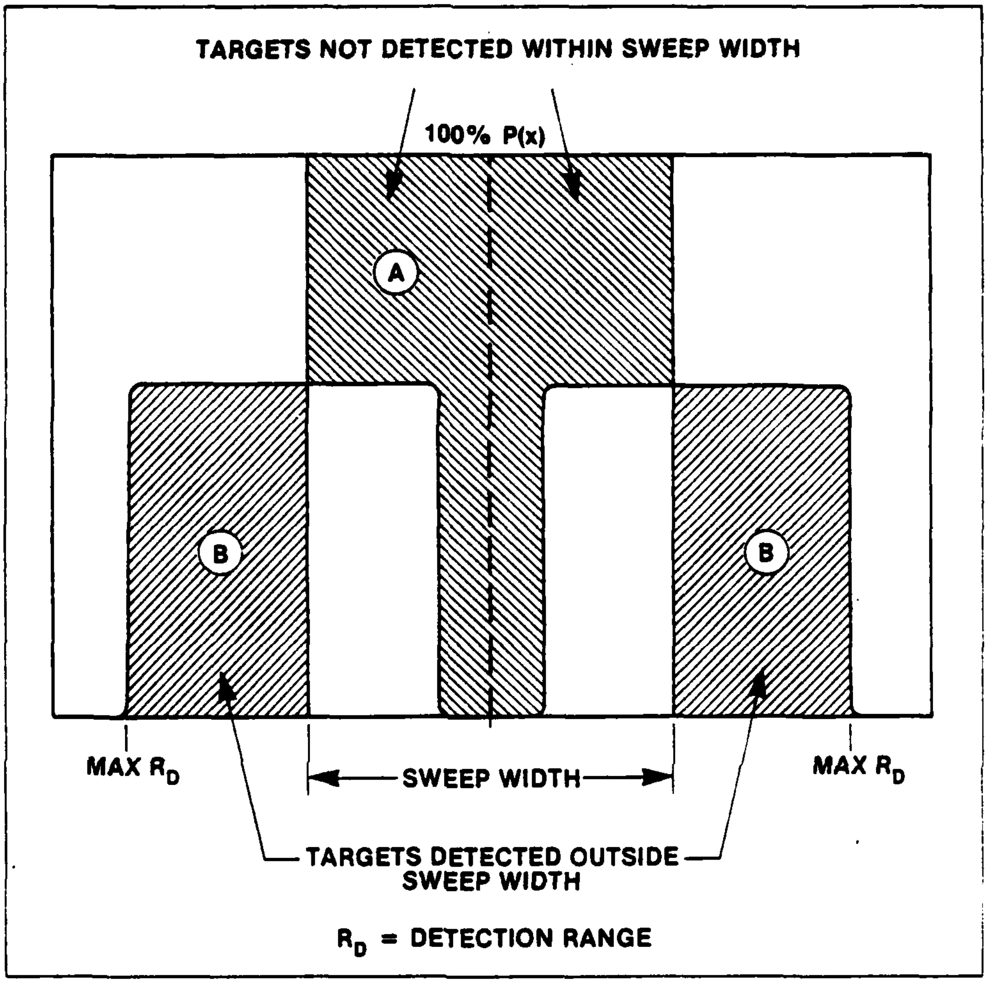


Figure 1-3. Definition of Lateral Range

Figure 1-4 shows a typical detection probability P(x) versus lateral range curve for electronic sensors such as SLAR. Electronic sensors perform differently than the human eye or other optical sensors over lateral ranges in that they obey a definite detection law-type function; that is, they operate with a fairly uniform P(x) out to their maximum range, and detect no targets beyond that range. For targets which provide a strong signal reflection and are large enough not to fall subject to any shadowing effects, this P(x) is typically near unity. For targets which provide weak signal reflections near the threshold of a sensor's capability to detect, and which might become subject to shadowing effects, this P(x) can drop well below unity. The "hole" in the P(x) versus lateral range curve near the searcher's track is due to the antenna pattern (blind zone). A portion of the search area directly underneath the transmitter is not illuminated because the electronic signal is not aimed vertically downward, but off to the side. The size of this area depends on altitude and the angle through which the signal is transmitted. In the case of SLAR, the width of this zone is approximately equal to twice the aircraft's altitude.

Conceptually, sweep width is the numerical range value obtained by choosing the distance from any given search track which will yield a number of detections beyond the sweep width range equal to the number of targets missed

A. GRAPHIC PRESENTATION OF SWEEP WIDTH



B. PICTORIAL PRESENTATION OF SWEEP WIDTH

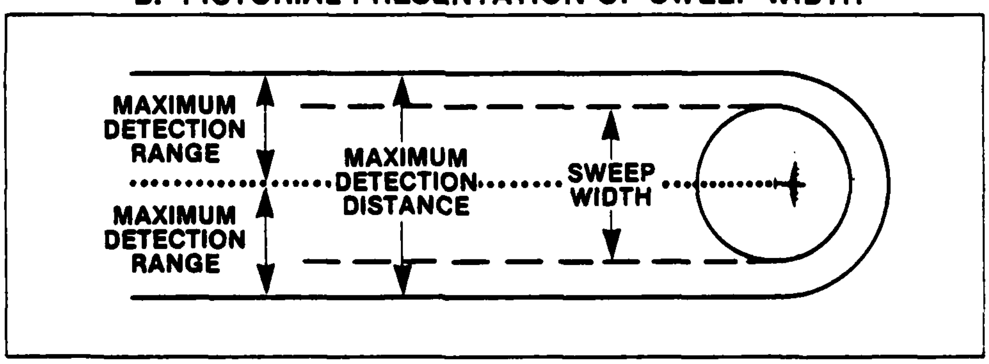


Figure 1-4. Graphic and Pictorial Presentation of Sweep Width

at ranges less than or equal to the sweep width. Figure 1-4 graphically presents this concept of sweep width. The number of targets missed inside the sweep width distance is indicated by the shaded area near the top middle of the rectangle (area A) while the number of targets sighted beyond the sweep width distance is indicated by the shaded areas at each end of the rectangle (area B). Referring only to the shaded areas, when the number of targets missed equals the number of targets sighted (area A = area B), sweep width is defined. A detailed mathematical development of sweep width can be found in Search and Screening (Reference 6).

For visual searches, the SAR Manual (Reference 7) uses sweep width to calculate a quantity known as coverage factor (C), which in turn is used to predict cumulative probability of detection (POD) for a given search. This model is based upon the assumption that the instantaneous glimpse probability of detection is inversely proportional to the cube of the range to the target. It should be noted that for SLAR this assumption is not valid. Thus, the SAR Manual procedure may not yield an accurate POD prediction. Additional discussion on this matter is provided in Chapter 4.

1.4 PARAMETERS WHICH MAY INFLUENCE SLAR SEARCH PERFORMANCE

Although SLAR has obvious advantages over visual search in poor or zero visibility conditions as well as a very sophisticated position marking and recording system, its performance is susceptible to certain controllable parameters as well as some environmental conditions. For example, high sea state (which is related to high wind speed) can increase the amount of backscatter received by the SLAR system, creating a "noisy" background in the image it produces, and making it difficult to identify targets of small or moderate size. The microwave signal also may be affected by the moisture content of the air through which it must propagate. Search altitude may affect the area size which will be covered by the SLAR signal as well as the width of the blind zone underneath the aircraft's flight path. Gain, antenna polarization, and target/size composition are also potentially significant parameters in SLAR detection performance.

Variables which are assessed in this report for their effects on SLAR detection performance are summarized below:

Environment-Related Variables	Controllable Variables
Wind speed	Target size and composition
Swell height	Antenna polarization
Relative humidity	Gain
Precipitation	Altitude
Image background	Lateral range
Visibility	

The environment-related variables primarily affect return signal strength and image quality while controllable variables affect the amount of area searched, type and strength of signal transmitted, and target resolution.

1.5 SUMMARY

While the AOSS SLAR and SLAR/RIP systems being evaluated in this report are designed primarily for ELT, oil spill surveillance, ice floe mapping, and iceberg tracking, they have a potential use as SAR sensors. The most important application of SLAR to SAR operations would be under conditions which render other search techniques ineffective or impossible.

SLAR detection performance can potentially be influenced by a number of parameters, some of which are controllable (at least to some extent) and others which are more environment-related. A preliminary investigation into the influence of these parameters on SLAR detection of small and moderate size targets was made during a series of three experiments which took place during late 1978 and through 1979. This report presents an analysis of the results of those experiments.

Chapter 2

EXPERIMENT DESIGN, CONDUCT, AND ANALYSIS APPROACH

2.1 GENERAL DESCRIPTION

The data used for this report were collected during three experiments during fall 1978, winter 1979 and fall 1979. To maximize resources, a SLAR aircraft was originally planned for 30 of the 69 visual search days scheduled between 11 September 1978 and 25 October 1979. However, due to operational commitments, equipment failures and adverse weather, only 5 days of AOSS SLAR and 6 days of SLAR/RIP data were collected. Table 2-1 provides the salient characteristics of the three experiments as well as a spring 1979 experiment in which no SLAR/RIP data could be collected.

a. Fall 1978 AOSS SLAR Searches. The AOSS SLAR aircraft conducted SLAR searches on 20 and 21 September in conjunction with a visual detection experiment in Block Island Sound. Targets were small boats and the monitor vessel, which was the On Scene Commander's (OSC) 42-foot Coast Guard utility boat (UTB).

b. Winter 1979 AOSS SLAR Searches. The AOSS SLAR aircraft conducted simultaneous SLAR and visual searches on 26, 27, and 31 January in conjunction with a leeway drift experiment in the open ocean off the Florida coast. Targets were drifting life rafts.

c. Fall 1979 SLAR/RIP Searches. The SLAR/RIP aircraft conducted SLAR searches in conjunction with another Block Island Sound visual detection experiment during September and October 1979. Targets were small boats, life rafts, 41- and 44-foot boats including the OSC vessel, and 82- and 95-foot cutters.

The search area for each SLAR experiment was partially controlled by the size and geographical features of the visual search area. Area size assigned to SLAR aircraft varied from 500 to 1500 nm^2 as shown in Figure 2-1. (Figure 2-1 also shows the microwave ranging system (MRS) configuration used

Table 2-1. Description of Individual Experiments

Experiment	Inclusive Dates	Location	Type of SLAR Tested	Target Types & (No. of Detection Opportunities)
Visual/SLAR detection experiment Fall 1978	11 September - 6 October	Block Island Sound	AOSS SLAR	Small boats (outboard or inboard/outboard) (93) 42' boat (30)
Leeway drift experiment Winter 1979	26-31 January	Atlantic Ocean off Florida Coast	AOSS SLAR	Life rafts (74)
Visual/SLAR detection experiment* Spring 1979	16 April - 22 May	Block Island Sound	SLAR/RIP	Life rafts, outboards, 42' boat (0)
Visual/SLAR detection experiment Fall 1979	17 September - 25 October	Block Island Sound	SLAR/RIP	Small boats (outboard) (160) Life rafts (114) 41' and 44' boats (125) 82' and 95' cutters (87)

*No SLAR/RIP data collected

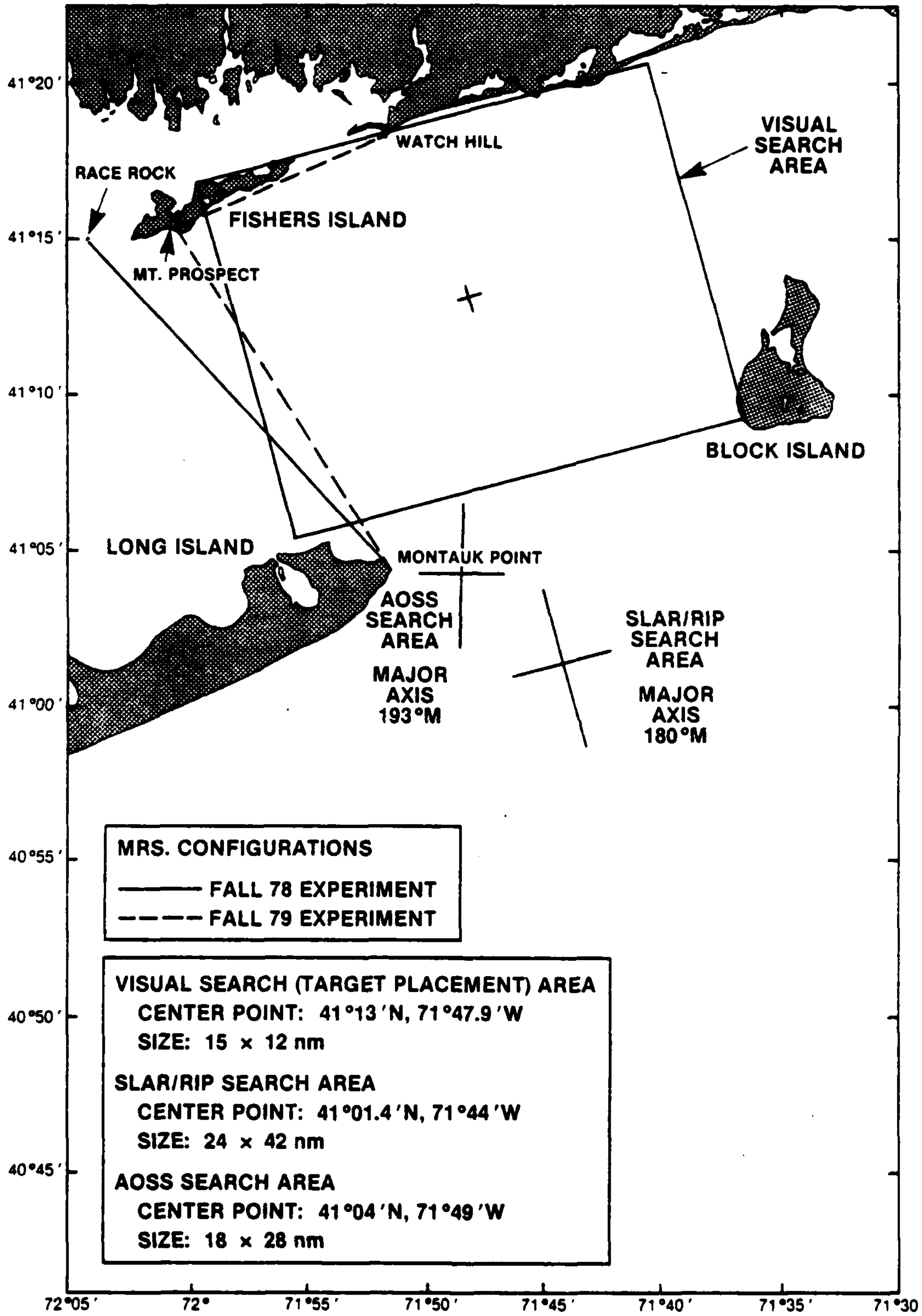


Figure 2-1. Search Areas in Block Island Sound and MRS Configuration

for target location.) The Block Island Sound SLAR search area varied from 18 X 28 nm centered at 41°04.0'N, 71°49'W to 24 X 42 nm centered at 41°01'N, 71°44'W. The open ocean searches were in a 30 X 50 nm area centered near 29°00'N, 77°00'W (exact center point coordinates varied daily as targets drifted).

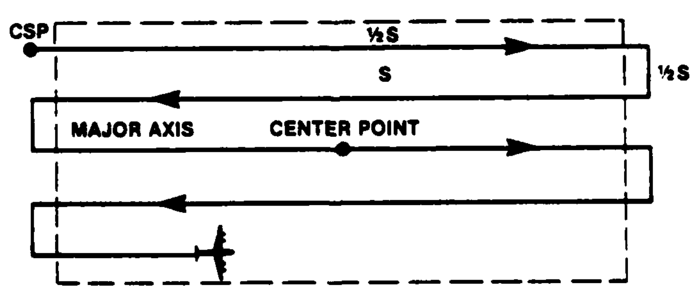
Chapter 3 presents the results of the three SLAR experiments. A complete description of the visual detection experiments is in Reference 8.

2.2 SEARCH PATTERNS

Four search patterns were used to collect SLAR data. Originally, one experiment objective had been to collect real-time SLAR detection data as well as recorded data for post-experiment analysis. For this reason, parallel (PS) or creeping line (CS) search tracks (Reference 7) were often used as they would be in an actual SAR mission, especially where visual search might be employed simultaneously. When no real-time data collection was intended, a box pattern search outside the perimeter of the area or a series of "fly-bys" past the targets was conducted.

2.2.1 Parallel Search

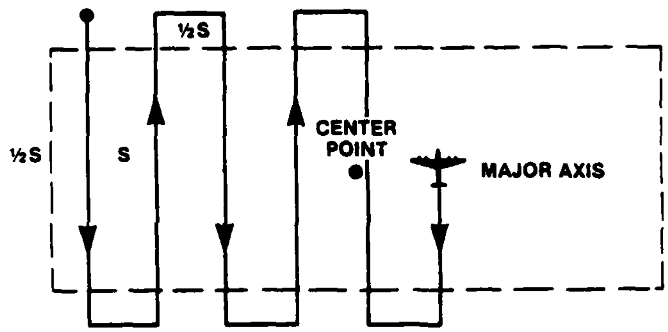
Search legs were parallel to the direction of the major axis of the search area and were separated by a specified track spacing. Commence search points (CSP) and outer search legs were one-half the track spacing (S) outside the perimeter of the search area to allow for uniform SLAR coverage (aircraft in level flight).



Sketch 1. Parallel Search Pattern

2.2.2 Creeping Line Search

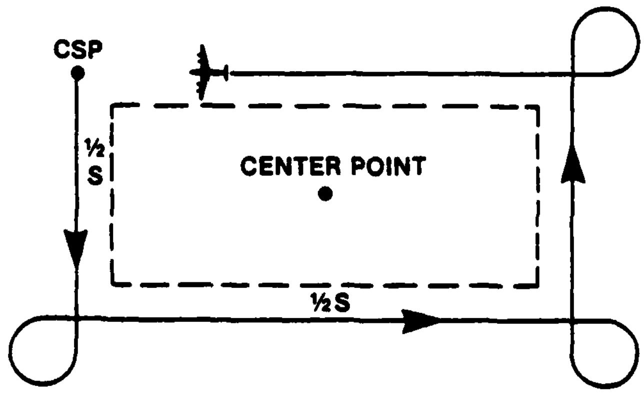
Search legs were perpendicular to the direction of the major axis of the search area and were separated by a specified track spacing. Start points and outer search legs were one-half the track spacing outside the perimeter of the search area.



Sketch 2. Creeping Line Search Pattern

2.2.3 Box Pattern

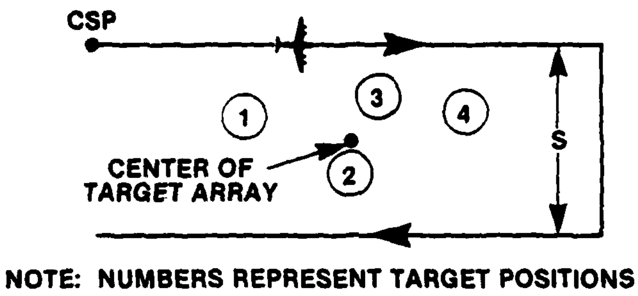
Search legs were parallel to the boundaries of the visual search area and one-half the track spacing outside. Turns were made at a standard rate away from the search area.



Sketch 3. Box Pattern

2.2.4 Fly-by

During the January 1979 experiment, a series of trackline (TS) fly-bys past the area containing targets was made in addition to the PS searches. This allowed altitude to be varied while other parameters such as range remained unchanged.



Sketch 4. Fly-by Pattern

2.3 TARGETS AND TARGET PLACEMENT

Actual search targets are typically life rafts, small to medium sized boats, or persons in the water (PIW) for SAR and medium to large boats or ships for ELT missions. The detectability of these targets by radar is dependent upon their material construction as well as their size. To determine the detection capability bounds for SLAR, small non-reflective targets (life rafts and small fiberglass boats) and large highly reflective targets (82 or 95-foot CG cutters) were used to represent the extremes of target detectability.

2.3.1 Target Types

Individual targets varied from experiment to experiment, but can generally be classified into three categories:

a. Small Boats. The average length was 16 feet, with the targets varying from 13 to 21 feet long. All were of fiberglass or aluminum construction, but the amount of equipment varied from none to a small amount of hardware to an inboard/outboard motor.

b. Life Rafts. Four- to seven-man life rafts were equipped with a four-foot high canopy or had only approximately two feet of freeboard. During the fall 1979 SLAR/RIP experiment, small corner-type radar reflectors were installed on some of the canopied rafts. All rafts were of rubber or nylon/rubber construction.

c. Larger Targets. Medium and large boats constructed of wood, fiberglass, aluminum or steel represent a large segment of recreational and commercial vessels and are the most detectable targets subject to SAR and ELT radar surveillance. Medium and large targets used in this experiment were 41/42/44-foot Coast Guard boats and 82/95-foot cutters. These vessels served as SLAR targets while acting as search and rescue units (SRUs) for collection of visual detection data. Since these vessels were primarily constructed of metal and large enough not to be subject to shadowing effects from small ocean swells, it was expected that they would be easily detected by both SLAR systems.

Table 2-2 summarizes the characteristics of all target types used during these experiments.

2.3.2 Target Placement

In all cases, prior to the exercise, track spacing had been estimated to provide maximum coverage of the visual search area and SLAR swath overlap so that targets of opportunity would appear on successive tracks. When appropriate, changes in track spacing were made by the OSC. SLAR search track spacing of 4 or 6 miles was used for all targets and environmental conditions. Small targets (either boats or life rafts) were anchored at predetermined locations and their positions marked by the OSC vessel.

Table 2-2. Description of SLAR Targets

Target	Size - L x H x W (ft)	Construction Material	Reflective Equipment
Life raft	12 x 2 x 5.5	Rubber	None
Life raft with canopy	6.2 x 3.8 x 6.2	Rubber, nylon	Radar reflector (selected cases)
Outboard	15 x 1.7 x 5.5	Fiberglass	Cleats, seat posts
Inboard/outboard	20 x 2 x 6	Fiberglass, aluminum	Engine, gas tank, etc
CG boat (UTB, MLB)	41/42/44 x 20 x 10	Aluminum, steel	Fully equipped
CG cutter (WPB)	82/95 x 40 x 15	Aluminum, steel	Fully equipped

For the Block Island Sound experiments, a microwave ranging system (MRS) was used to accurately mark the initial location of small anchored targets (life rafts, outboards, and inboard/outboards). Additionally, at the end of each search day, target fixes were again taken to ensure that drifting had not occurred. The above procedure was accomplished by taking fixes on the OSC vessel (which was equipped with an MRS transponder) as it set or picked up a target. On some occasions the end-of-day checks indicated that targets had drifted from their initial positions. These targets were eliminated from the data base since their position at any time during the search could not be confirmed.

Larger targets were all equipped with MRS transponders and were tracked constantly by the system. Fixes on these targets were recorded at 3 to 5 minute intervals and are estimated to be accurate to within 0.1 nm. A more detailed description of the MRS function can be found in Reference 8. Figure 2-1 shows the location of MRS baselines and transmitting stations used in Block Island Sound.

During the leeway drift experiment off the Florida coast, MRS direct-range readings coupled with visual bearings from CGC EVERGREEN (the OSC vessel) yielded accurate target position fixes relative to the EVERGREEN every 15 minutes. Since the EVERGREEN was always clearly visible on the SLAR film recordings, target identification was made possible. The absence of miscellaneous contacts in the open ocean also made target identification easier for this experiment.

2.4 RECONSTRUCTION

The reconstruction methods used to determine target detections and misses differed for the three SLAR experiments because of differences between the AOSS SLAR and SLAR/RIP systems, radar contact congestion in the search area, or target positioning and identification methods. The reconstruction of each experiment is discussed in the following sections.

In all three experiments the aircraft's search track was recorded by an *inertial navigation system* (INS). INS error was continuously checked in Block Island Sound by comparing the known latitude and longitude of geographical points of reference with those recorded on the SLAR display. If the search aircraft are equipped with a mobile MRS transponder in future experiments, reconstruction will be much faster and more accurate because both target and searcher positions will be measured by the same system.

2.4.1 Fall 1978 AOSS SLAR Searches

During the fall 1978 experiment in Block Island Sound, SLAR data was gathered on small boats and the monitor vessel (42-foot UTB) using the AOSS HC-130 aircraft (CG 1347) from CGAS Elizabeth City. Detection and misses were determined as follows.

a. Obtain number of detection opportunities.

   (1) Determine the locations of the targets in the search area using data provided by the MRS.

(2) Determine track of aircraft by reviewing videotapes.

(3) Extract INS positions and corresponding times from videotapes.

(4) Plot locations and flight tracks to determine number of detection opportunities.

b. Determine detections and misses.

(1) Review SLAR film, which is annotated with information including time and aircraft position, to locate geographical points of reference in order to determine INS errors.

NOTE: The SLAR film was analyzed rather than the videotapes because the videotape could not be stopped to observe scenes.

(2) Apply INS errors to determine corrected target locations on the film.

(3) Examine each corrected target location and surrounding area to determine if a detection or miss occurred.

2.4.2 Winter 1979 AOSS SLAR Searches

During the winter 1979 experiment, an AOSS HC-130 aircraft was again used to gather SLAR data. Targets were life rafts drifting in the open ocean about 300 nm off the Florida Coast. Detections and misses were determined as follows.

a. Obtain number of detection opportunities.

(1) Reconstruct the flight tracks using data from the onboard line printer which recorded time and aircraft position every 30 seconds.

(2) Determine life raft locations in relation to the OSC monitor vessel (CGC EVERGREEN) which was in the vicinity of the drifting life rafts.

(3) Plot target locations and flight tracks to determine number of detection opportunities.

b. Determine detection and misses.

(1) Locate monitor vessel on SLAR film.

NOTE: INS errors could not be determined due to the absence of fixed geographical points of reference. CGC EVERGREEN became the reference point for determining the target area instead.

(2) Search the appropriate areas around the monitor vessel to determine if a detection or miss occurred.

2.4.3 Fall 1979 SLAR/RIP Searches

During the fall 1979 experiment in Block Island Sound, SLAR data was gathered by the SLAR/RIP HC-130 aircraft (CG 1351) from CGAS Clearwater. Data was collected on detection of life rafts with and without radar reflectors, small fiberglass boats, 41-foot CG UTBs, 44-foot CG motor lifeboats (MLBs), and 82-foot and 95-foot CG cutters. The SLAR/RIP equipment was operated by personnel from the NASA Lewis Research Facility in Cleveland, Ohio. The SLAR/RIP data was on magnetic tape and post-experiment analysis was conducted using NASA computer facilities at their Image Processor Data Reduction Center. Detections and misses were determined as follows.

a. Determine number of detection opportunities.

(1) Determine target locations (i.e., number of detection opportunities) outside the blind zone using data provided by the MRS.

(2) Review video tape. (Flight track reconstruction was unnecessary since the computer software allowed one to search beyond the blind zone anywhere along the flight track while reviewing the SLAR tape.)

b. Determine detections and misses.

(1) Compute INS errors from geographical points and apply to target locations.

(2) Input corrected target locations (latitude and longitude) to the computer.

(3) Examine the vicinity of corrected target positions for SLAR contacts. It should be noted that some personal judgement was required in the determination of small target detections. In the case of larger targets, there was seldom any question as to the validity of a contact. In instances where extraneous contacts of similar reflectivity occurred near a larger target, detections could be verified by defining that target location more precisely on the viewing screen.

2.5 DATA COLLECTION TECHNIQUES AND DATA ACCURACY

Although the data were analyzed after the flights, an attempt was made to review the SLAR films and tapes as if it were a real-time situation. Real-time analysis of the data was felt to be impractical due to the extraneous target concentration in the case of Block Island Sound, and the fact that the number of targets and their location were not known by the searchers. In an operational search mode, a SLAR would probably not be used in a high target density area since visual identification of each possible SLAR target would be very time consuming and inefficient.

During the experiments, the number and positions of actual targets were known but radar contacts were not identified visually. Therefore, the lack of

proof that a contact in the target area was, in fact, a target became a problem. A degree of uncertainty exists with some of the SLAR detections and misses described earlier. There was no way to circumvent this problem because the targets were placed randomly in the search area on any given day to meet visual search requirements.

To distinguish a detection from a miss the following criteria were used in post-experiment analysis.

a. A detection occurred when:

   (1) A target of expected radar image intensity appeared in the corrected target position.

b. A miss occurred when:

   (1) A potential target location was masked by background noise of intensity equal to or greater than the target.

   (2) The area of corrected target position was devoid of contacts.

c. All other cases (i.e., doubt of target position, uncertainty as to which target was subject) were eliminated from the data base.

Because of the uncertainty of target location or identification, much data was lost (i.e., 30 percent of life raft and small boat detection opportunities during the fall 1979 experiment). However, this problem area can be easily remedied in future SLAR tests by making the following design changes:

a. Set targets in a distinguishable pattern.

b. Select search area with few targets of incidence.

c. Use a range of target sizes, construction materials, and reflective materials simultaneously.

d. Use a highly reflective target as a "beacon".

Further discussion of future experiment design is presented in Chapter 4.

2.6 EXPERIMENT DESIGN CONSIDERATIONS

In all three experiments, SLAR data were being collected as a secondary objective to the acquisition of visual detection or drift data. The primary objective for SLAR data collection, then, was to gather enough information to identify broad limits within which SLAR can operate as a useful SAR sensor. These experiments were designed with this objective in mind rather than with the intent to compile a comprehensive data base upon which exhaustive statistical analysis could be conducted.

Because the original intention was to collect both real-time and post-flight analysis detection data, standard search patterns were most often flown and crews were instructed to operate the SLAR equipment as they saw fit. While this approach did not permit all of the independent variables to be controlled systematically, it did facilitate an evaluation of SLAR capability to detect the targets used over the range of environmental parameters which were encountered.

2.7 DESCRIPTION OF EXPERIMENT CONDITIONS

2.7.1 Detection Opportunities

The three SLAR experiments yielded a total of 197 detection opportunities on three types of target for the AOSS SLAR system and 486 detection opportunities on four types of target for the SLAR/RIP system. Target types fall into three general categories as described in Section 2.3.1, but specifics varied from one experiment to another. Table 2-3 summarizes SRU resource commitments during the three experiments and the total number of detection opportunities which occurred for each target type.

Table 2-3. Summary of SRU Resources

SLAR Type	Target Type	Total Search Time* (hours)	Total Mission Time* (hours)	Total Number of Detection Opportunities
AOSS	Outboards	4.2	-	63
AOSS	Inboard/outboards	4.2	-	30
AOSS	42' boats	4.2	35.5	30
AOSS	Life rafts	6.9	58.0	74
SLAR/RIP	Life rafts	9.4	-	114
SLAR/RIP	Outboards	12.8	-	160
SLAR/RIP	41'/44' boats	16.0	-	125
SLAR/RIP	82'/95' cutters	9.3	171.7	87

*NOTES:
1. Search time is defined as the cumulative number of hours each aircraft spent searching only during the SLAR experiments.
2. Mission time includes hours spent equipping for the SLAR experiments, hours spent on-scene, and hours spent transitting to and from the test area except when engaged in other operational missions.
3. Total mission time is only listed once for the fall 1978, winter 1979, and fall 1979 experiments because different target types were used during each mission.

2.7.2 Range of Parameters

Environmental parameters varied somewhat from one experiment to another and some controllable parameters such as altitude and gain were varied over a different range of values for different target types. Table 2-4 summarizes the range of parameter values investigated in each data base. In some data bases, pairs of variables were found to be directly related; e.g., wind speed and swell height; SLAR/RIP operators tending to increase gain settings at higher altitudes.

Table 2-4. Range of Parameters Investigated for Each Data Base

SLAR Type	Target Type	Lateral Range (nm)	Altitude (ft)	Wind Speed (knots)	Swell Height (ft)	Antenna Polarization	Gain	Relative Humidity (%)	Precipitation
AOSS SLAR	Life rafts	.1 - 12	500 - 5000	10 - 30	1.5 - 3	Vertical and horizontal	N/A	60 - 100	Clear fog rain
	Small boats	0 - 13	1000 - 3300	3 - 12	1 - 4	Vertical and horizontal	N/A	55 - 71	None
	42' boat	.5 - 12	1000 - 3300	3 - 12	1 - 4	Vertical and horizontal	N/A	55 - 71	None
SLAR/RIP	Life rafts	.7 - 36	1000 - 7500	4 - 17	0 - 3	Horizontal	1 - 7	54 - 91	None
	Small boats	.7 - 35	2000 - 5000	4 - 17	0 - 3	Horizontal	2 - 7	82 - 100	Clear fog rain
	41'/44' boats	1.3 - 35	1000 - 7500	4 - 17	0 - 3	Horizontal	1 - 7	78 - 100	Clear fog rain
	82'/95' cutters	1.3 - 35	2000 - 5000	4 - 9	0 - 3	Horizontal	2 - 6	54 - 94	None

2.8 ANALYSIS APPROACH

2.8.1 Introduction

It is again emphasized that the size and scope of this data base is not sufficient to warrant exhaustive statistical analysis. For this reason, simple analytical techniques were generally used to look at experimental results. These techniques consisted primarily of binning and plotting the empirical data to compare SLAR detection performance under sets of conditions which might demonstrate the influence of certain parameters. An exception to this approach was made with the SLAR/RIP data involving small boat targets. Examination of this data base indicated that application of a multivariate regression model known as LOGODDS might provide information about interrelated variables which would not be obtainable using simpler methods.

2.8.2 Raw Data

Raw data was compiled during the reconstruction process as described in section 2.4. Raw data sheets were completed for each SLAR type/target type combination separately. Information recorded on these sheets included the time at which each opportunity for detection occurred, a detection/miss indication, and the following parameters of interest:

a. Lateral range (nm)
b. Altitude (ft)
c. Visibility (nm)
d. Wind speed (knots)
e. Swell height (ft)
f. Antenna polarization (vertical or horizontal)
g. Background (clear or dark)
h. Power (full or split for AOSS, gain setting for SLAR/RIP)
i. Relative humidity (hundredths)
j. Precipitation (yes or no)
k. Target type designator

Computer data files were created using these raw data sheets and are included as Appendix A.

2.8.3 Aggregation of Data

Because of inherent differences between the two SLAR systems and among the various target types used in the experiments, aggregation of data was limited to similar SLAR type/target type combinations. Although preliminary examination of results indicates that aggregation of certain data bases may be appropriate, too many questions remain unanswered to justify doing so at this time.

2.8.4 Analysis of Empirical Data

As expected, both SLAR systems achieved excellent results in detection of 41- to 95-foot targets. This performance allowed conclusions about SLAR detection of these targets under the range of environmental conditions encountered to be drawn with a minimum of analytical effort.

For each of the four small-target data bases, opportunities were binned according to detections and misses so that any general differences in the conditions which characterized them could be ascertained. These differences were used to identify initial questions for investigation. Scatter diagrams similar to Figure 2-2 were used to define the range of parameter values present in each data base. From this information, binning schemes were devised which would allow the data to be sorted so that reasonable sample size could be maintained while examining the effects which various parameters had on detection performance.

Some questions which were identified required comparison of detection performance for different altitudes, clear versus dark image background, various wind speeds, and horizontal versus vertical AOSS antenna polarization. The ratio of detections/opportunities in each lateral range bin was used to develop probability of detection P(x) versus lateral range for each of the four data bases. This indicated that there was an identifiable lateral range

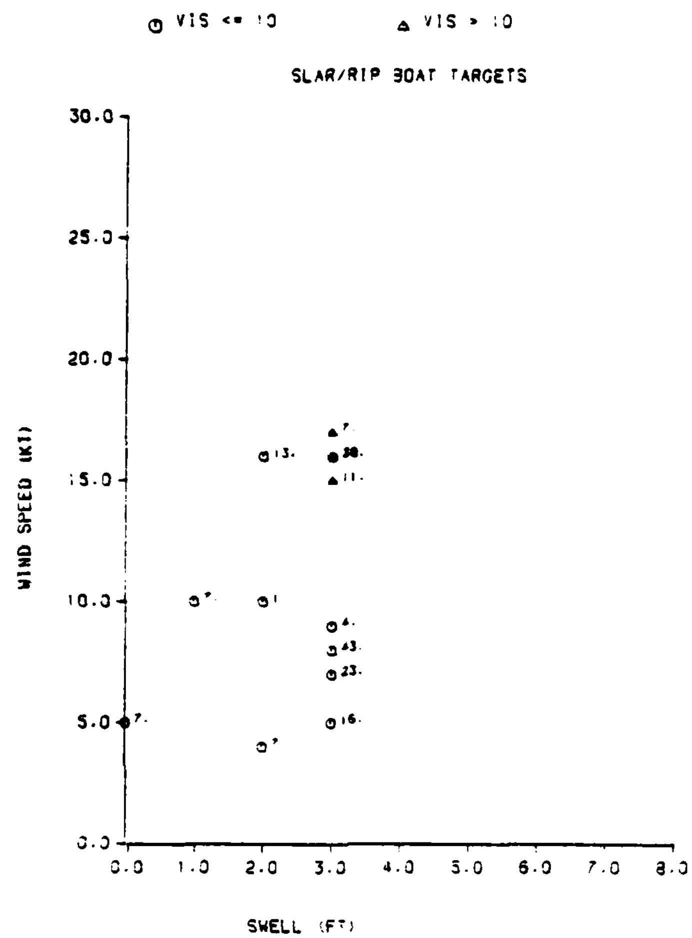


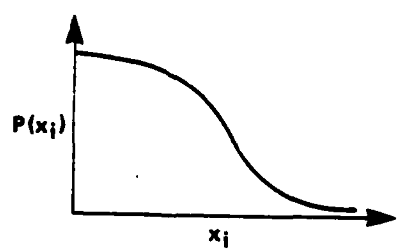
Figure 2-2. Sample Scatter Diagram for SLAR Data

interval over which SLAR detected small targets with a fairly consistent P(x). These plots were similar in shape to the lateral range curve depicted in Figure 1-4. Overall, the data indicated that lateral ranges of 2 to 18 nm included nearly all opportunities on small targets where a significant chance for detection existed. For this reason, <u>only opportunities occurring in the 2 to 18 nm lateral range interval were used to investigate the influence of other parameters on target detection probability P(x).</u>

2.8.5 Use of LOGODDS Model

The data base representing SLAR/RIP detection of small boats was the largest and, therefore, the best suited to investigation of more complex relationships between parameters. From empirical data plots, it was determined that image background, altitude, precipitation, and wind speed might potentially influence SLAR detection performance. Computer files, including only these parameters along with a detection/miss indicator, were created so that the LOGODDS regression model could be run for this data base.

The LOGODDS model has been used successfully in analyzing visual detection data from these same experiments (References 8 and 9). This regression technique is a tool which has proven useful in finding the best quantitative relationship between independent variables (x_i) and a probability of interest $P(x_i)$. The independent variables can be continuous (e.g., wind speed or altitude) or binary (e.g., light/dark image background or precipitation/no precipitation). Experience has indicated that data which exhibits classic stimulus-response (S-R) behavior as shown below is best suited to this regression technique.



Whereas lateral range has been shown to be the most significant independent variable in regression of visual detection data, empirical plots demonstrated that SLAR probability of detection varies in this fashion more with wind speed. As mentioned earlier, SLAR probability of detection does not behave in S-R fashion over lateral range.

The equation LOGODDS uses is:

$$P(x_i) = \frac{1}{1 + e^{-\lambda}}$$

where

$$\lambda = a_0 + a_1x_1 + a_2x_2 + a_3x_3 \cdot \cdot \cdot$$

a_i = constants (determined by computer program) and

x_i = independent variable values

Since LOGODDS was only used in a limited sense for analysis of the SLAR data, further description of this multi-regression technique is not included. Refer to appendix A of Reference 9 for a complete description and discussion of the LOGODDS model.

Chapter 3
ANALYSIS RESULTS AND CONCLUSIONS

3.1 INTRODUCTION

Sections 3.2 through 3.7 describe AOSS SLAR and SLAR/RIP detection performance for the target types described in Chapter 2. Section 3.8 compares SLAR P(x) versus lateral range curves with those of visual search and discusses sweep width as a measure of effectiveness for SLAR search.

Results are based on post-experiment analysis of SLAR video tape and film recordings. Real-time analysis was not conducted because the high volume of boat traffic in Block Island Sound prevented operators from distinguishing valid targets from miscellaneous contacts and, therefore, real-time detections could not be verified.

3.2 SLAR DETECTION OF MEDIUM AND LARGE TARGETS

Table 3-1 shows the number of opportunities and detections for larger targets. All AOSS SLAR opportunities occurred at lateral ranges less than 12 nm because only the 25 km display scale was used. Thus, the data did not give a maximum detection range for 42-foot targets. The SLAR/RIP system yielded detection opportunities for the 41-, 44-, 82-, and 95-foot targets at much longer lateral ranges. Under moderate environmental conditions, detection of these targets was still not affected by lateral range in the 1.3 to 35 nm interval.

Table 3-1. Opportunities and Detections: SLAR Searching for Medium and Large Targets (All Lateral Ranges Included)

SLAR Type	Target Type	Number of Opportunities	Number of Detections
AOSS SLAR	42' boats	30	26
SLAR/RIP	41'/44' boats	125	124
	82'/95' cutters	87	87

There was nothing about the environmental parameters associated with the five misses on 41- and 42-foot targets that clearly distinguished them from detections. Four of the five misses occurred with the AOSS SLAR system, however, which suggests that testing of both systems under identical conditions should be considered for comparison purposes.

3.3 AOSS SLAR DETECTION OF SMALL BOATS

The parameters investigated include antenna polarization, image background, wind speed, and target composition. Figure 3-1 shows a target detection probability P(x) versus lateral range plot of the empirical data sorted into 2 nm lateral range bins. No consistent variation in P(x) with lateral range is apparent between 2 and 13.5 nm, while only one detection was made in 22 opportunities at lateral ranges of less than 2 nm.

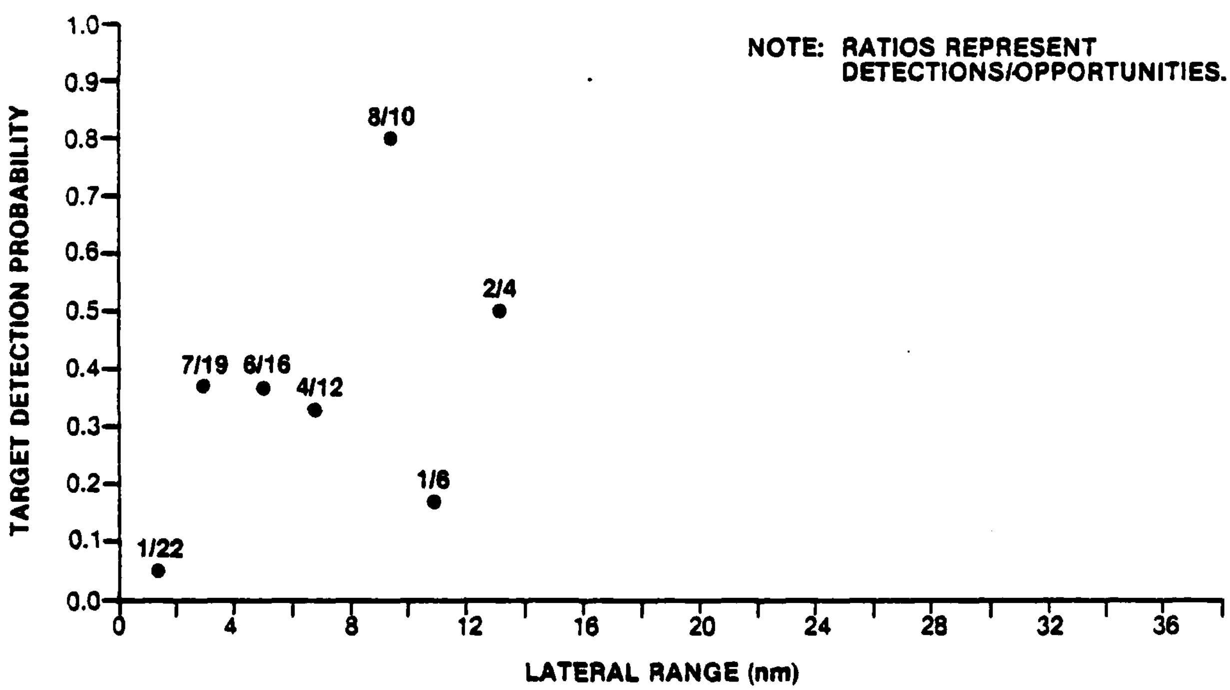


Figure 3-1. Empirical Success Ratios Versus Lateral Range for AOSS SLAR Searching for Small Boats

Figure 3-2 illustrates the difference in performance between vertically and horizontally polarized AOSS SLAR antennas. This result is consistent with findings of Vollmers et al. (Reference 2) that the horizontally polarized AOSS antenna is better at detecting "hard" targets.

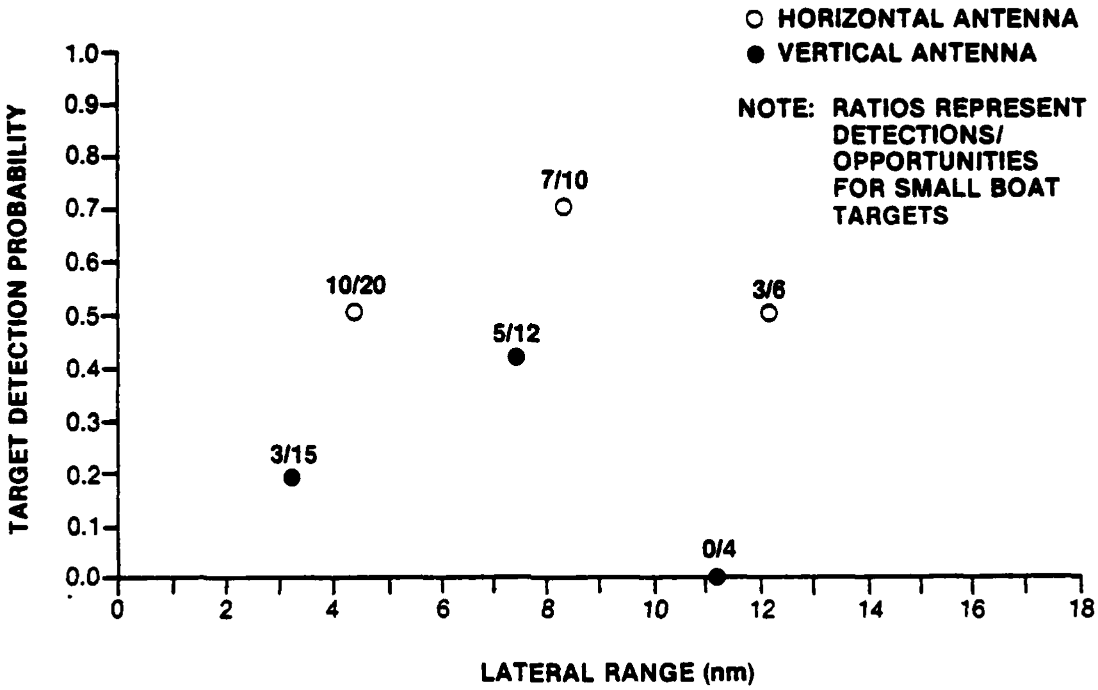


Figure 3-2. AOSS SLAR: Horizontal Versus Vertical Antenna Polarization (Lateral Range ≥ 2 nm)

Data was binned into background, wind speed, and target type categories to examine the effects of those parameters on P(x). Table 3-2 summarizes the results of this binning procedure. Mean values of other variables of interest are included in each bin for comparison purposes. The table shows that higher wind speeds and sea states are more likely to cause darkening or "noise" in the SLAR image, making detection of small targets more difficult.

Slightly larger targets containing more hardware (e.g., inboard/outboard engine, metal hull, seat posts, gas tank) should be better reflectors of the SLAR microwave signal, and this appears to be supported by the data. It must

Table 3-2. Influence of Parameters of Interest on AOSS SLAR Detection of Small Boats (Lateral Ranges ≥ 2 nm)

Variable of Interest	Detections/ Opportunities	Target Detection Probability	Average Conditions: Altitude (ft)	Average Conditions: Wind Speed (knots)	Average Conditions: Sea Height (ft)	Average Conditions: Background (% scattered/ dark)	Remarks
Background							
Clear/light	23/38	.61	1866	6.5	1.9	0	
Scattered/dark	5/29	.17	1044	10.5	3.2	1.00	Higher wind speed and sea height characteristic of dark background
Wind Speed (knots)							
≤ 10	22/41	.54	1712	5.9	1.5	.24	
> 10 to 20	6/26	.23	1192	11.8	4.0	.73	Higher wind speed and sea height characteristic of dark background
Target Type							
19' - 21' fiberglass or aluminum w/full equipment and I/O motor	16/25	.64	1550	4.7	1.4	.23	
13' - 15' fiberglass w/o equipment	12/42	.29	1294	10.4	3.1	.67	P(x) for this target type may be lower partly due to differences in environmental conditions.

be noted, however, that opportunities for detection on these targets occurred under generally better environmental conditions.

Altitude did not vary greatly, so the effects which this parameter may have on SLAR detection of small targets were not assessed in this report.

3.4 AOSS SLAR DETECTION OF LIFE RAFTS

As shown in Figure 3-3, AOSS SLAR detection of life rafts was extremely poor due to the following:

a. Prevailing wind speeds were higher than in any other data base. Higher wind speed also adversely affected SLAR detection of small targets in every other data base. Higher wind speed and sea state cause the SLAR image to be generally noisier, making discrimination of weak signal reflections from background very difficult.

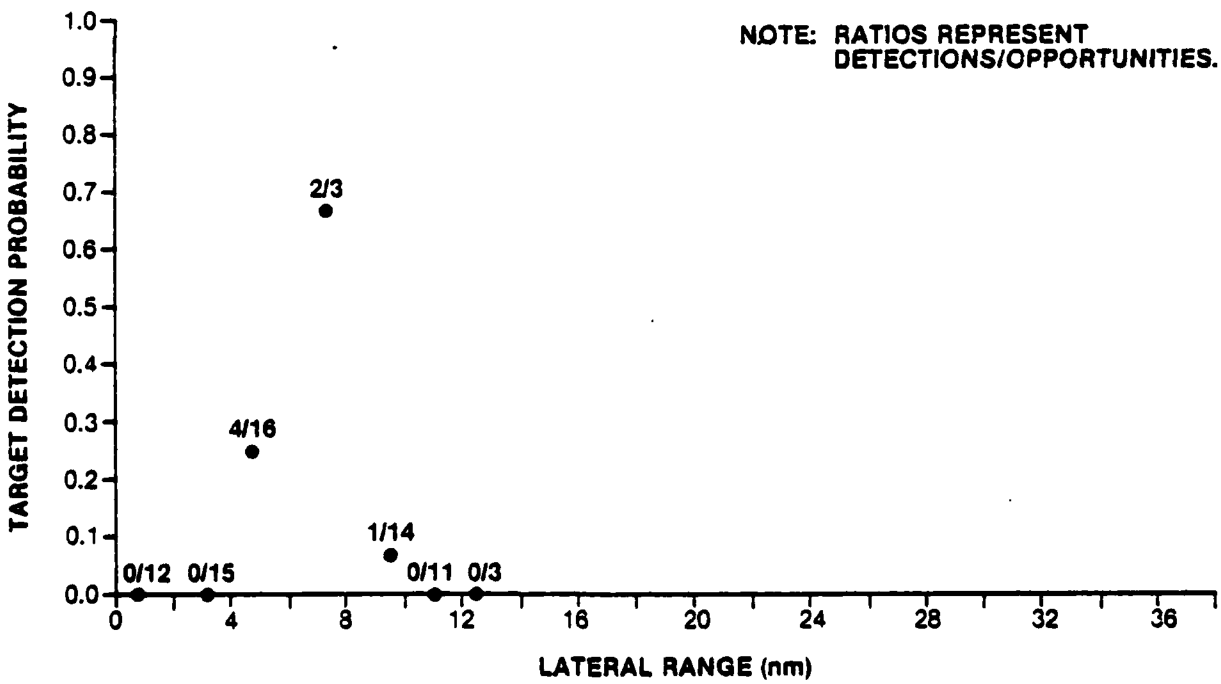


Figure 3-3. P(x) Versus Lateral Range for AOSS SLAR Searching for Life Rafts

b. The vertically polarized antenna was used in over half the opportunities occurring at lower (10- or 20-knot) wind speeds. Data presented in section 3.3 indicated that this antenna does not detect small targets very well even under better conditions.

Table 3-3 presents the results of binning this data into three wind speed categories. These results support the explanation offered above for generally poor performance of AOSS in detecting life rafts. While there was a wide distribution of altitude in the data due to conduct of several fly-by searches at various altitudes, this parameter could not be examined for its influence on detection because of the overriding effects of wind speed.

Table 3-3. Effects of Wind Speed on AOSS SLAR Detection of Life Rafts (Lateral Ranges ≥ 2 nm)

Wind Speed (knots)	Detections/ Opportunities	Target Detection Probability	Altitude (ft)	Sea Height (ft)	Background (% scattered/ dark)	Antenna Polarization (% vertical)
10	5/28	.18	3175	1.8	.57	.57
20	2/15	.13	2200	3.0	1.00	.60
30	0/20	0	1600	3.0	.85	.35

3.5 SLAR/RIP DETECTION OF SMALL BOATS

Parameters investigated in this data base include wind speed, image background, altitude, target composition, and precipitation. Because of the size of this data base and range of parameters encountered, the LOGODDS regression model was used as an analytical tool in addition to binning.

Figure 3-4 presents a P(x) versus lateral range plot of the empirical data sorted into 2 nm lateral range bins. Only three opportunities for detection occurred at lateral ranges less than 2 nm, so short-range SLAR/RIP

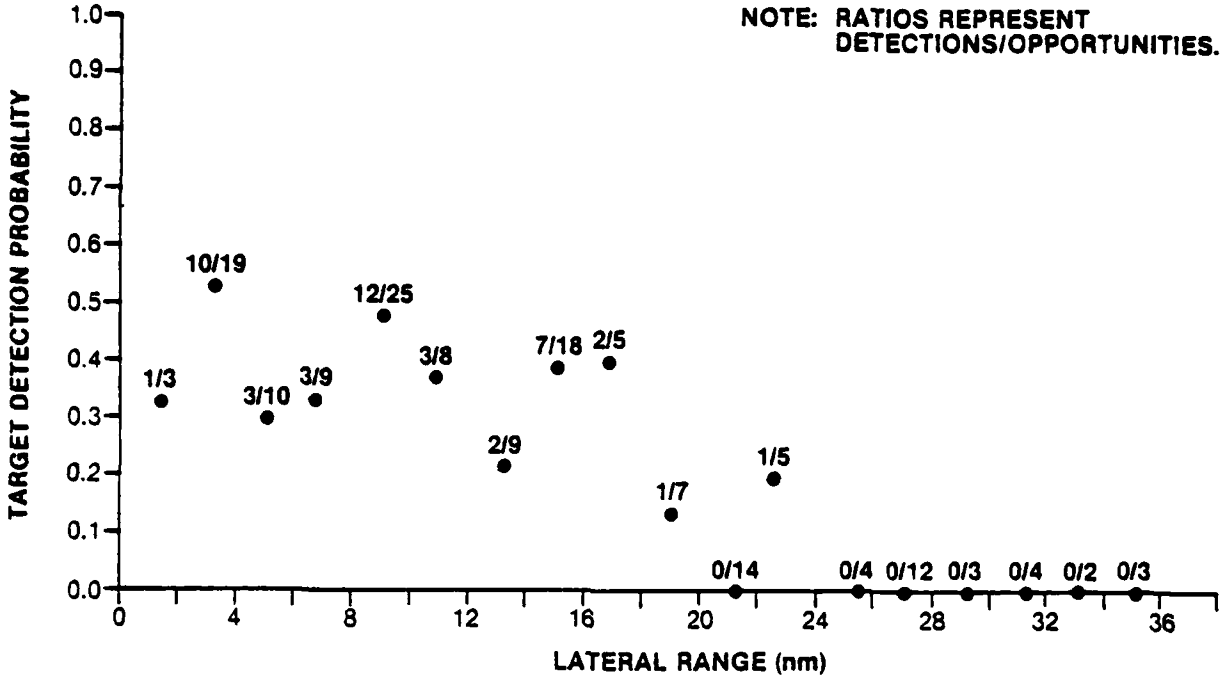


Figure 3-4. P(x) Versus Lateral Range for SLAR/RIP Searching for Small Boats

detection of small boats cannot be assessed using this data. The ability of SLAR/RIP to detect these targets seems to deteriorate quickly beyond 18 nm, although too little data exist to pinpoint a maximum detection range for given sets of parameter values. P(x) in the 2 to 18 nm lateral range interval falls fairly consistently into the 0.25 to 0.55 region.

Table 3-4 summarizes the results of binning this data into appropriate intervals of wind speed, background, altitude, target type, and precipitation. Mean values of other parameters of interest in each bin are again included for comparison purposes. General trends which can be identified from the data are:

a. High wind speed and dark image background are closely associated with one another. Their presence results in substantially lower detection probability for small boats.

Table 3-4. Influence of Parameters of Interest on SLAR/RIP Detection of Small Boats (Lateral Ranges 2 - 18 nm)

Variable of Interest	Detections/ Opportunities	Target Detection Probability	Average Conditions: Altitude (ft)	Wind Speed (knots)	Sea Height (ft)	Background (% scattered/ dark)	Precipitation (% when present)	Antenna Gain (Setting)
Wind Speed (kts)								
≤ 10	37/72	.51	3389	7.0	2.6	.28	.07	4.7
> 10 to 20	5/31	.16	3258	15.9	2.7	.71	.45	3.8
Background								
clear/light	32/61	.52	3704	8.1	2.6	0.0	.08	4.7
scattered/ dark	10/42	.24	2833	12.0	2.6	1.00	.33	4.0
Precipitation								
None	38/84	.45	3298	8.6	2.7	.33	0.0	4.4
Present	4/19	.21	3579	14.4	2.1	.74	1.00	4.6
Altitude (ft)								
2000	6/32	.19	2000	9.7	2.4	.53	.16	3.5
3000	20/37	.54	3000	10.3	2.5	.54	.16	4.5
5000	16/34	.47	5000	8.9	2.9	.15	.24	5.2
Target Type								
15' or 17' fiberglass w/ limited equipment	19/51	.37	3216	10.2	2.6	.39	.06	4.1
13' - 15' fiberglass shell	23/52	.44	3481	9.1	2.6	.42	.31	4.7

b. Presence of precipitation may also contribute to dark image background and thus lower target detection probability, but its effect cannot easily be distinguished from that of higher wind speed.

c. The altitude/gain setting combination of 3000'/4.5 yielded the best detection performance under conditions which were similar to those encountered at other combinations. These two parameters are considered together because SLAR operators tended to raise the gain setting at higher search altitudes.

d. Larger boats with some hardware were no more detectable than the smaller targets.

To investigate in a more sophisticated manner the effects which wind speed, background, precipitation, and altitude had on P(x), the LOGODDS regression model was run with the experiment data. At the 90-percent confidence level, it was found that wind speed and altitude were significant in explaining variability of P(x) for data in the 2 to 18 nm. lateral range interval. Wind speed was found to be the more influential of the two variables. Figure 3-5 illustrates the LOGODDS regression fits for target detection probability versus wind speed at altitudes of 2000, 3000, and 5000 feet. For comparison, the empirical data used by the model is binned by altitude and by windspeed ($\leq$10 knots or >10 knots) and plotted. It is apparent from Figure 3-5 that, for the range of parameters present in this data base, wind speed and altitude determined SLAR performance to a large extent.

3.6 SLAR/RIP DETECTION OF LIFE RAFTS

Wind speed, image background, altitude, and raft type were examined for their effects on target detection probability in this data base. P(x) versus lateral range is plotted in Figure 3-6 while Table 3-5 presents results of binning the data on variables of interest.

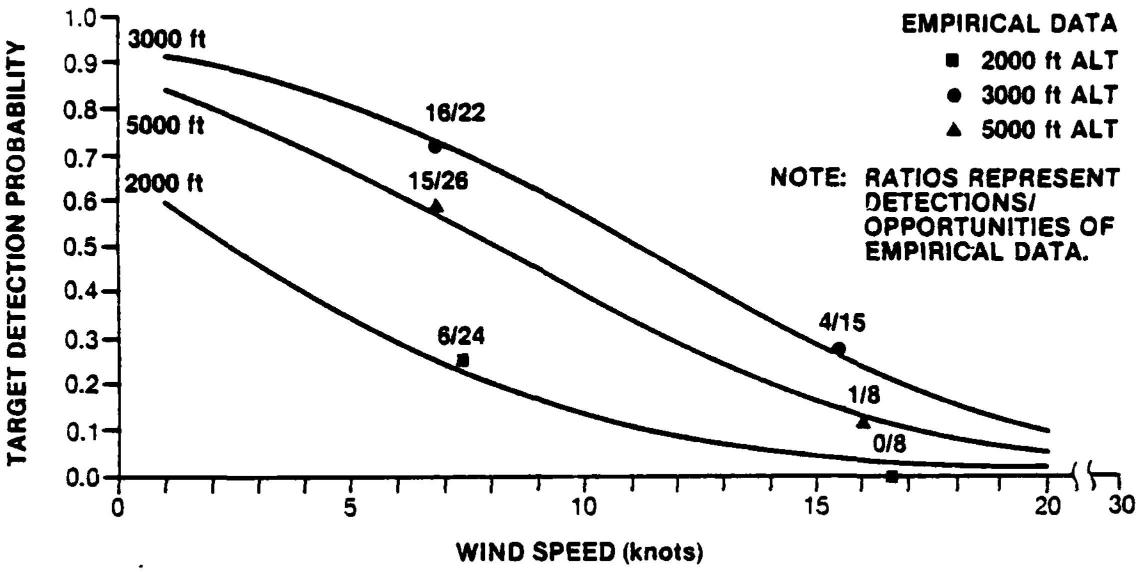


Figure 3-5. LOGODDS Regression Fits of Target Detection Probability Versus Wind Speed at Various Altitudes (SLAR/RIP Searching for Small Boats: 2 to 18 nm Lateral Ranges)

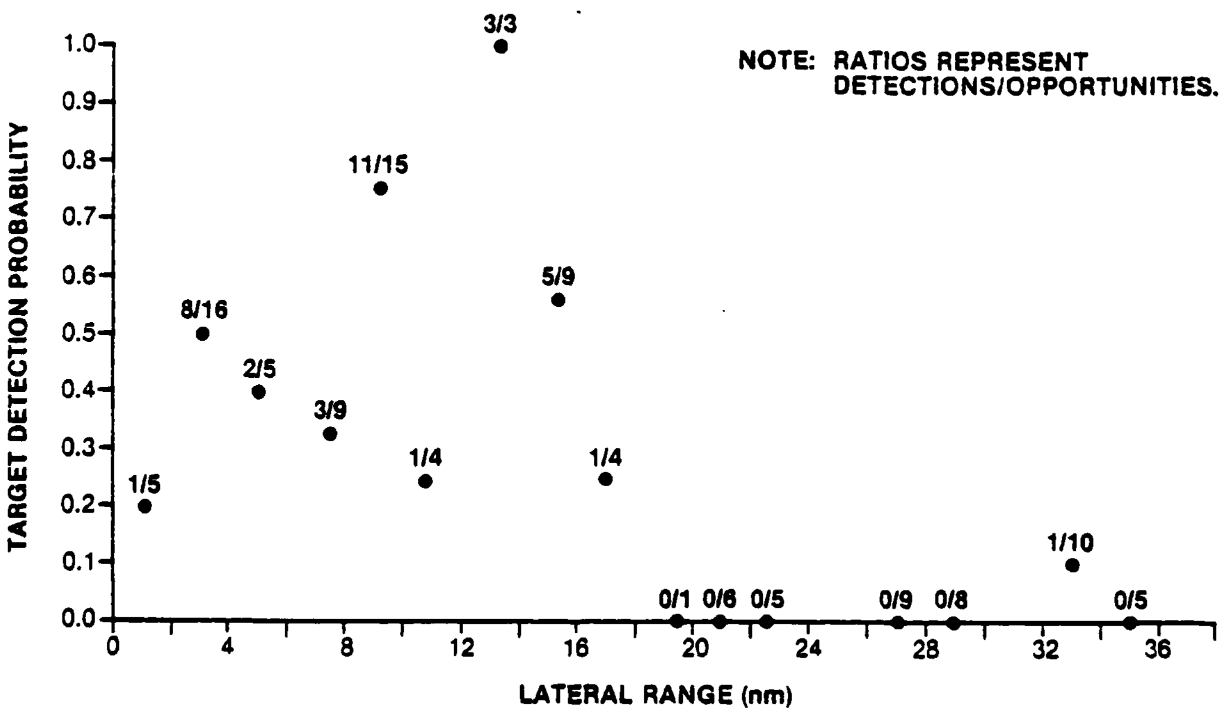


Figure 3-6. P(x) Versus Lateral Range for SLAR/RIP Detection of Life Rafts

Table 3-5. Influence of Parameters of Interest on SLAR/RIP Detection of Life Rafts (Lateral Ranges 2 to 18 nm)

			Average Conditions				
Variable of Interest	Detections/ Opportunities	Target Detection Probability	Altitude (ft)	Wind Speed (knots)	Sea Height (ft)	Background (% scattered/dark)	Antenna Gain (Setting)
Wind Speed (knots)							
≤ 10	33/53	.62	3368	5.6	0.2	.25	5.0
> 10 to 20	1/12	.08	2000	15.3	2.8	.50	2.1
Background							
Clear/light	30/43	.70	3023	6.6	0.5	0.0	4.4
Scattered/dark	4/22	.18	3295	8.9	1.1	1.00	4.6
Raft Type							
Canopied w/ reflector	10/16	.62	3531	4.9	0.1	.19	4.9
Canopied w/o reflector	5/22	.23	2727	11.2	1.7	.50	3.6
w/o canopy or reflector	19/27	.70	3185	5.6	0.2	.30	4.9
Altitude							
1000	0/3	0.0	1000	14.0	2.0	.33	1.0
2000	9/21	.43	2000	8.3	.86	.52	3.8
3000	21/30	.73	3000	6.5	.47	.10	4.6
5000	3/6	.50	5000	5.0	.33	.17	6.0
7500	0/5	0.0	7500	7.0	1.0	.60	7.0

While the lateral range plot of Figure 3-6 exhibits more scatter than that of Figure 3-4, smaller sample size is probably more responsible for this than major differences in SLAR performance. The lateral range interval of 2 to 18 nm still contains the only significant opportunities for detection. The single detection which occurred at lateral range beyond 30 nm was on a life raft equipped with a corner-type radar reflector.

Although the presence of a corner radar reflector did not significantly enhance life raft detectability for the SLAR/RIP system, it is postulated that the small size of the corner radar reflectors used makes detection susceptible to target aspect. Thus, a single occurrence of greater detection range occurred but consistent improved performance was not achieved.

The low detection probability associated with canopied orange rafts may likely be due to the much higher mean wind speed and darker background associated with those detection opportunities.

While very little data existed to evaluate 1000-, 5000-, and 7500-foot altitude performance, the difference in detections between 2000- and 3000-foot altitudes is noteworthy. Referring to Section 3.5, one finds that the same effect was also demonstrated with small boat targets. Before definitive conclusions about the effects of altitude on SLAR search performance can be drawn, however, further data should be collected. Since SLAR operators tended to increase gain setting with altitude while collecting this data, the influence of the two variables cannot yet be distinguished.

Finally, results shown in Table 3-5 indicate that high wind speed and dark background have the same adverse effects on SLAR detection performance as demonstrated in Tables 3-2, 3-3, and 3-4.

3.7 SUMMARY OF SLAR SEARCH PERFORMANCE

The two SLAR systems tested in these experiments performed in a manner which is represented by the lateral range curves of Figures 3-7 and 3-8.

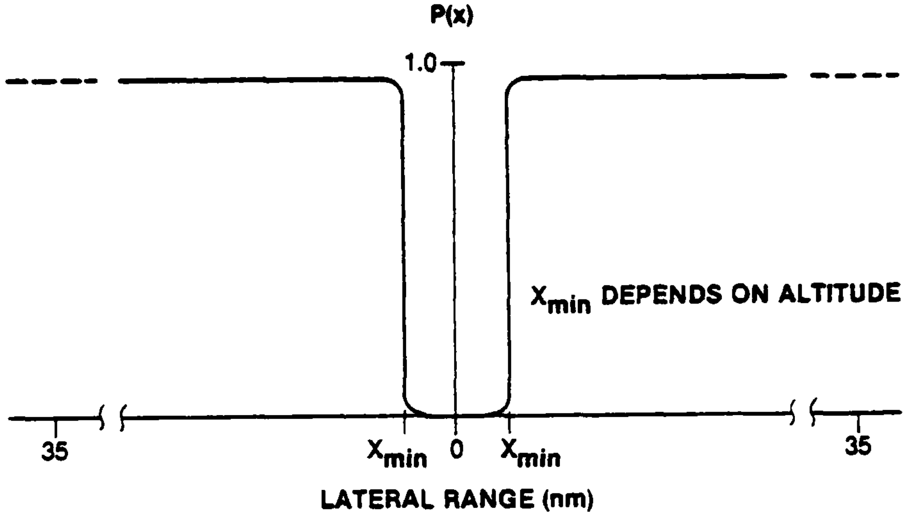


Figure 3-7. Estimated SLAR P(x) Versus Lateral Range Curve for Medium and Large Targets

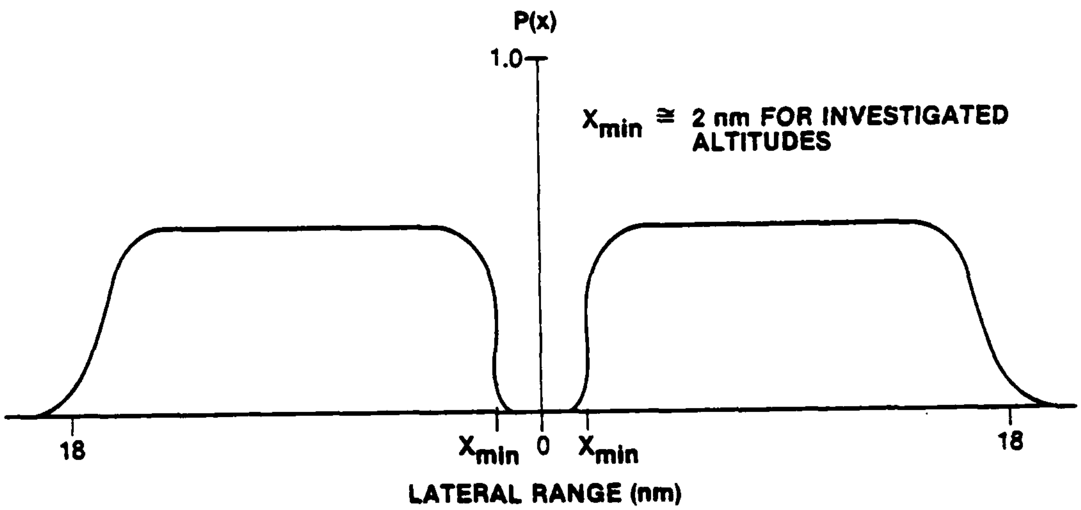


Figure 3-8. Estimated SLAR P(x) Versus Lateral Range Curve for Small Targets

For medium and large size targets in moderate conditions, target detection probability P(x) is very near unity beyond lateral ranges subject to the blind spot discussed in Chapter 1. No maximum lateral range for SLAR detection of these targets has been determined since performance was constant out to the maximum range tested (35 nm).

Smaller targets were not as detectable, and SLAR search performance with them was much more sensitive to changes in environmental and system parameters. The data which have been collected thus far indicates that detection probability is in the 50 percent range for small targets under moderate conditions. SLAR detection performance for small targets at lateral ranges of less than 2 nm was low. The existence of the blind zone only explains target misses out to a range equal to the altitude. It is hypothesized that the additional low performance is caused by high sea return which is a function of altitude, gain setting and sea state. P(x) for small targets drops rapidly to zero beyond a lateral range of about 18 nm as shown in both SLAR/RIP data bases. No maximum lateral range for detection of small targets was determined for the AOSS SLAR because performance was constant out to the maximum range tested (13.5 nm).

Results of a preliminary experiment conducted in 1968 (Reference 10) with an APS-94C SLAR, while not directly analogous to those presented here, did indicate that similar performance was achieved by that system under moderate environmental conditions. In the 1968 experiment, 40- and 95-foot Coast Guard vessels were detected at 5 to 10 nm lateral ranges on 82 of 86 opportunities (95%). A 16-foot plastic boat with full equipment was detected on 22 of 43 opportunities (51%). It is emphasized that there are many differences in both experiment design and SLAR system parameters which make direct comparison of results presented in this report with those of the 1968 report inappropriate. The 1968 experiment is mentioned here for informational purposes only.

3.8 COMPARISON OF SLAR WITH VISUAL SEARCH

The lateral range curves presented in section 3.7 are much different in shape than those encountered with visual search. Figure 3-9 illustrates the difference in performance over lateral range for visual detection of orange canopied life rafts by aircraft (Reference 8) under good conditions and SLAR/RIP detection of small targets achieved during these experiments under good to moderate conditions. Both curves can be affected by changes in environmental conditions or sensor parameters (e.g., wind speed or antenna polarization for SLAR; visibility or time on task for visual), but their general shape should remain similar. It should be noted that the SLAR performance presented here is based on post-exercise analysis of the data; as such, it is an upper bound to performance achievable in a real-time search scenario.

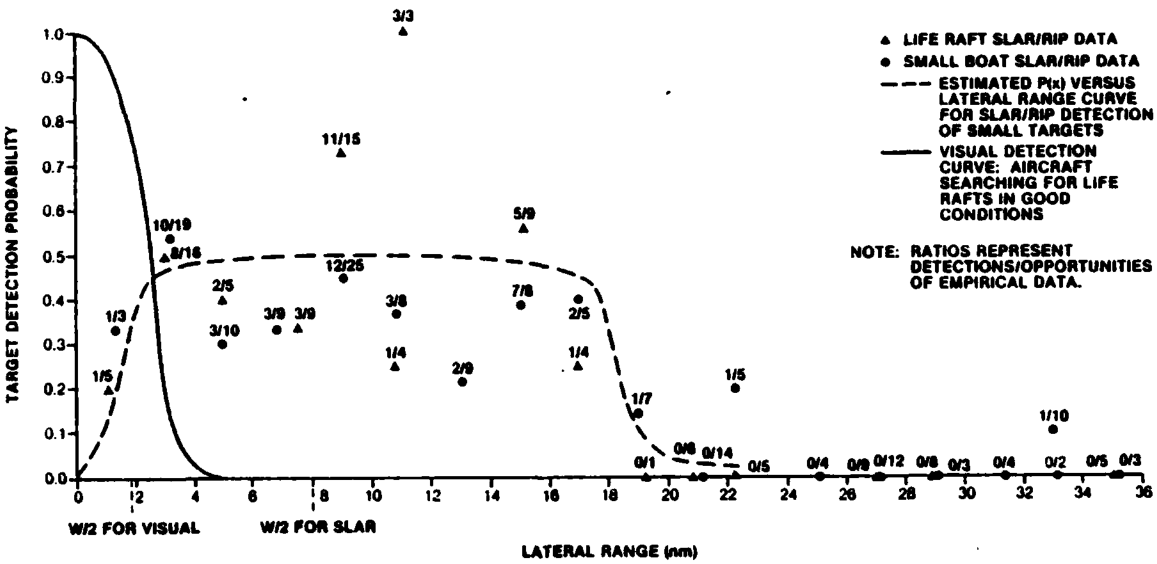


Figure 3-9. Comparison of SLAR/RIP and Visual Detection Probability Over Lateral Range for Small Targets

Sweep width (W) for the two sensors from the lateral range curves of Figure 3-9 is calculated as follows. For the visual detection curve, W is calculated using

$$W = \int_{-\infty}^{+\infty} P(x)\, dx$$

which yields a value of 3.7 nm according to Reference 8. For the SLAR detection curve, the integral can be approximated by

$$W = 2 \int_{X_{min}}^{X_{max}} P(x)\, dx = 2\, \overline{P}(x)\, (X_{max} - X_{min})$$

where

X_{min} = approximate minimum lateral range for SLAR detection of small targets (about 2 nm).

X_{max} = approximate maximum lateral range for SLAR detection of small targets (about 18 nm).

$\overline{P}(x)$ = Mean value of P(x) over the interval from X_{min} to X_{max} (about 0.5 in this example).

which yields a value of 16 nm for W. The one-half sweep width ranges of 1.85 nm for visual and 8 nm for SLAR are marked in Figure 3-9.

The interpretation of search performance differs with each sensor. The existing visual search measure uses sweep width to determine cumulative POD but is not appropriate for predicting SLAR detection performance (see Section 1.3). To illustrate SLAR potential only, a comparison with visual POD is made using the present SAR Manual method and the sweep widths determined from Figure 3-9. In the case of visual detection, if a parallel search pattern was flown using precise navigation with track spacing (S) equal to the sweep width (W), the lateral range curve would overlap itself on adjacent legs to provide

fairly uniform coverage of the search area, as shown in Figure 3-10. Assuming that the border area where no overlap of the lateral range curve occurs is small in relation to the rest of the search area, POD which is determined from the summation of P(x) is in the 90 percent bracket. For a SLAR search where S equals W, area coverage would not be so uniform, as shown in Figure 3-11. The blind zone of the SLAR produces strips of poor area coverage beneath the aircraft's flight path and the probability of detecting the target resulting from this type of search would be low (0.5) if the targets were located near the flight track or area border and higher (0.75) if the target were located between flight tracks. Since S for the SLAR search is approximately four times that of the visual, considerably less time is required per search. Therefore a larger area could be covered or successive SLAR searches could be conducted of the same area to raise the POD.

Since uniform coverage is desired, special search patterns for SLAR searches must be conducted. It is apparent from the preceeding examples that sweep width is of limited value to search planners in predicting SLAR performance and that cumulative probability of detection attained under certain conditions can be potentially higher than for visual search. As illustrated in Figure 3-9, combined visual and SLAR coverage should provide a higher POD for the areas and may be the ideal method of search. Further study is required to develop useful measures of SLAR and SLAR/visual performance for use in effectiveness prediction and optimal search planning.

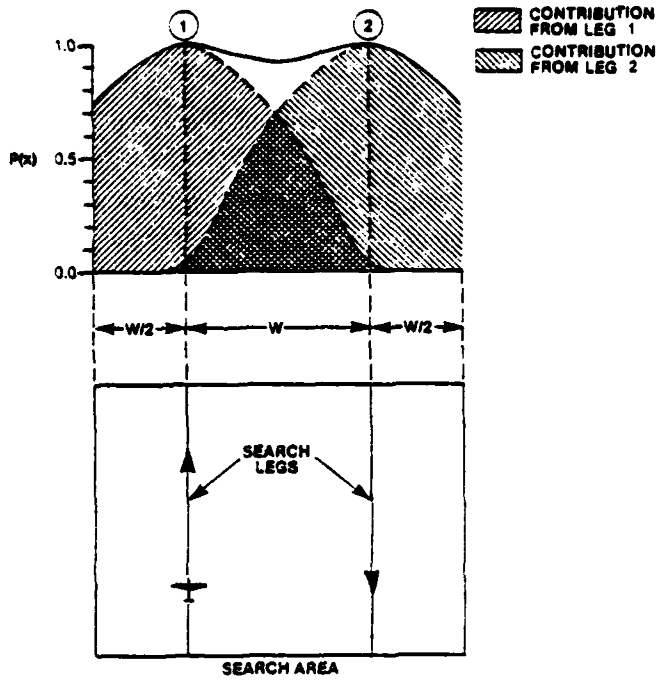


Figure 3-10. Example of Search Area Coverage for Visual Search

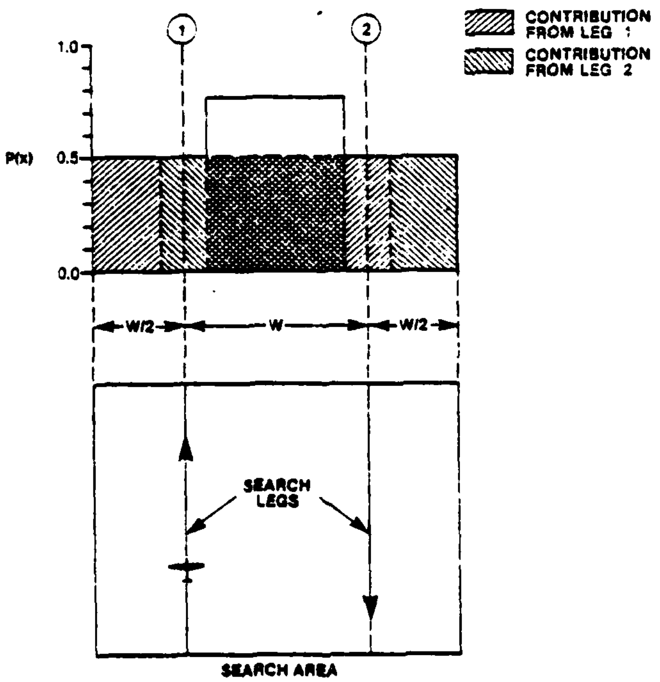


Figure 3-11. Example of Search Area Coverage for SLAR

Chapter 4
PLANNED WORK

4.1 FUTURE EXPERIMENTS

Additional experiments will be conducted in the near future as part of the Project Master Plan to achieve the following goals:

a. Collect sufficient data to quantify SLAR system performance under a variety of environmental conditions.

b. Define optimum values of controllable SLAR operating parameters for a variety of target types and environmental conditions.

c. Develop guidelines which will enable search planners to make the most efficient use of SLAR in SAR operations.

d. Develop appropriate measures of performance which will enable *cumulative probability of detection* (POD) to be predicted for SLAR searches.

e. Evaluate combined visual and SLAR search performance for development of efficient search techniques.

4.2 FUTURE EXPERIMENT DESIGN

Experience gained from these experiments and questions which have been identified for further investigation yield the following plans for future experiment design.

a. Data Collection

Since an upper bound on the capabilities of SLAR to detect common types of SAR target has not yet been determined, emphasis will be

placed on the collection of data for post-experiment analysis. This technique allows for easier verification of detections because target locations on the SLAR image are known to the experimenter. While analysis of this type of data will not necessarily reflect how well a SLAR operator can perform in a real-time search scenario, it will define an upper bound on how well the SLAR system itself can be expected to perform in detection of SAR targets.

The following approach to data collection is planned:

(1) Establish a fixed target zone for SLAR searches instead of assigning a large search area containing only a few targets.

(2) Set several targets of various types (different size, freeboard, construction, material) in this zone so that their comparisons can be made under similar conditions.

(3) Set one or more highly reflective beacon targets which will make location of other targets on the SLAR film or video tape much easier during post-experiment analysis.

(4) Conduct fly-bys past the target zone with system parameters (i.e., gain), altitude, or lateral range being varied as desired. This approach will result in a large amount of data being collected in a controlled, efficient manner.

(5) Collect data while flying both parallel and perpendicular to the direction of ocean wave propagation. It is possible that there are differences in the amount of sea-return received by the SLAR system using these two flight patterns.

b. Parameters

Parameters which will be investigated include, but are not limited to, the following:

(1) Target Materials. Small aluminum boats, boats fully equipped (outboard motors, gas tanks, etc.), 20- to 40-foot boats, and a variety of other target types (rafts, sailboats, fishing boats, etc.) will be used in addition to those tested already.

(2) Gain Selection. Optimum gain setting for various altitudes, target types, and environmental conditions will be determined.

(3) Altitude. An optimum search altitude may exist for a given target type. This parameter will be investigated over a wide range of values under similar sets of environmental conditions to determine if optimum values exist.

(4) Environment. Collect additional data to quantify the effects of wind speed and any other significant environmental parameters on SLAR detection performance.

(5) Reflective Devices. A wide variety of devices which are designed to enhance radar detectability of small craft will be tested.

(6) Lateral Range. Maximum and minimum lateral range of detection will be determined for various target types, environmental conditions, and search altitudes.

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Appendix A
RAW DATA

This appendix contains raw data files for individual SLAR units on a daily basis. Aggregate files were created for life rafts, small boats, and larger boats. Aggregate files were used in the binning of data and also for the LOGODDS computer model run.

The following is a key to the format of the data files:

Column 1: Detection (1 = yes, 0 = no)
Column 2: Lateral Range (nautical miles)
Column 3: Altitude (feet)
Column 4: Meteorological Visibility (nautical miles)
Column 5: Wind Velocity (knots)
Column 6: Swell Height (feet)
Column 7: Antenna Polarization (1 = vertical, 0 = horizontal)
Column 8: Image Background (1 = dark, 0 = light)
Column 9: Power (AOSS SLAR) (1 = one antenna, 0 = both antennae)
Column 9: Gain (SLAR/RIP) (setting selected)
Column 10: Relative Humidity (tenths)
Column 11: Precipitation (1 = present, 0 = none)
Column 12: Target Code (explained below)

Life Rafts	Small Boats	Coast Guard Boats and Cutters
1=Canopy and radar reflector	1,2= 13' fiberglass shell	1=42' boat
2=Canopy only	3-7=15' to 18' fiberglass	2=41' boat
3=No canopy or reflector	8=19' fiberglass I/O	3=44' boat
	9=21' aluminum I/O	4=82' cutter 5=95' cutter

HC130 20 SEPT 78 TARGETS:42'BOATS

1	5.50	3500.00	15.00	3.00	1.00	0.00	0.00	0.00	0.65	0.00	1.00
1	8.25	3500.00	15.00	3.00	1.00	1.00	0.00	0.00	0.65	0.00	1.00
1	11.20	3500.00	15.00	3.00	1.00	0.00	0.00	0.00	0.65	0.00	1.00
1	2.50	2000.00	15.00	3.00	1.00	0.00	0.00	0.00	0.55	0.00	1.00
1	6.80	2000.00	15.00	3.00	1.00	1.00	0.00	0.00	0.55	0.00	1.00
1	11.10	2000.00	15.00	3.00	1.00	0.00	0.00	0.00	0.55	0.00	1.00
1	10.05	1500.00	15.00	5.00	2.00	1.00	0.00	0.00	0.65	0.00	1.00
1	5.70	1500.00	15.00	5.00	2.00	0.00	0.00	0.00	0.65	0.00	1.00
1	2.15	1500.00	15.00	5.00	2.00	1.00	0.00	0.00	0.65	0.00	1.00
1	2.00	1500.00	15.00	5.00	2.00	1.00	1.00	0.00	0.65	0.00	1.00
1	2.35	1500.00	15.00	5.00	2.00	0.00	0.00	0.00	0.65	0.00	1.00
1	2.50	1500.00	15.00	5.00	2.00	0.00	0.00	0.00	0.65	0.00	1.00
1	3.50	1000.00	15.00	5.00	1.00	0.00	1.00	0.00	0.55	0.00	1.00
1	1.10	1000.00	15.00	5.00	1.00	0.00	1.00	0.00	0.55	0.00	1.00
1	6.80	1000.00	15.00	5.00	1.00	1.00	0.00	0.00	0.55	0.00	1.00
0	0.50	1000.00	10.00	7.00	1.00	0.00	1.00	0.00	0.65	0.00	1.00
1	4.25	1000.00	10.00	7.00	1.00	0.00	0.00	0.00	0.65	0.00	1.00
0	3.58	1000.00	10.00	7.00	1.00	0.00	1.00	0.00	0.65	0.00	1.00
1	9.20	1000.00	10.00	7.00	1.00	1.00	0.00	0.00	0.65	0.00	1.00
1	11.90	1000.00	10.00	7.00	1.00	0.00	0.00	0.00	0.65	0.00	1.00

HC130 20 SEPT 76 TARGETS: 16 BOATS

1	5.40	3500.00	15.00	3.00	1.00	0.00	0.00	0.00	0.63	0.00	9.00
1	9.90	3500.00	15.00	3.00	1.00	0.00	0.00	0.00	0.63	0.00	8.00
0	11.20	3500.00	15.00	3.00	1.00	0.00	0.00	0.00	0.63	0.00	2.00
1	9.50	3500.00	15.00	3.00	1.00	1.00	0.00	0.00	0.63	0.00	9.00
1	13.30	3500.00	15.00	3.00	1.00	0.00	0.00	0.00	0.63	0.00	9.00
1	5.35	2000.00	15.00	3.00	1.00	0.00	0.00	0.00	0.55	0.00	9.00
1	11.10	2000.00	15.00	3.00	1.00	0.00	0.00	0.00	0.55	0.00	2.00
1	9.90	2000.00	15.00	3.00	1.00	0.00	0.00	0.00	0.55	0.00	8.00
1	9.50	2000.00	15.00	3.00	1.00	1.00	0.00	0.00	0.55	0.00	9.00
1	13.30	2000.00	15.00	3.00	1.00	0.00	0.00	0.00	0.55	0.00	9.00
1	7.90	1500.00	15.00	5.00	2.00	1.00	0.00	0.00	0.63	0.00	9.00
1	6.20	1500.00	15.00	5.00	2.00	0.00	0.00	0.00	0.63	0.00	2.00
0	11.00	1500.00	15.00	5.00	2.00	0.00	0.00	0.00	0.63	0.00	8.00
1	3.60	1500.00	15.00	5.00	2.00	0.00	0.00	0.00	0.63	0.00	9.00
0	0.00	1500.00	15.00	5.00	2.00	1.00	0.00	0.00	0.63	0.00	9.00
1	7.32	1500.00	15.00	5.00	2.00	1.00	0.00	0.00	0.63	0.00	8.00
1	3.35	1500.00	15.00	5.00	2.00	0.00	0.00	0.00	0.63	0.00	8.00
0	4.10	1500.00	15.00	5.00	2.00	1.00	1.00	0.00	0.63	0.00	9.00
1	4.60	1500.00	15.00	5.00	2.00	0.00	0.00	0.00	0.63	0.00	9.00
1	3.05	1500.00	15.00	5.00	2.00	1.00	0.00	0.00	0.63	0.00	8.00
0	0.85	1500.00	15.00	5.00	2.00	0.00	0.00	0.00	0.63	0.00	9.00
1	5.25	1000.00	15.00	5.00	1.00	0.00	1.00	0.00	0.55	0.00	8.00
0	0.90	1000.00	15.00	5.00	1.00	0.00	1.00	0.00	0.55	0.00	2.00
0	6.70	1000.00	15.00	5.00	1.00	0.00	0.00	0.00	0.55	0.00	9.00
1	3.00	1000.00	15.00	5.00	1.00	0.00	0.00	0.00	0.55	0.00	2.00
1	2.95	1000.00	15.00	5.00	1.00	0.00	0.00	0.00	0.55	0.00	2.00
0	1.55	1000.00	15.00	5.00	1.00	1.00	1.00	0.00	0.55	0.00	8.00
0	5.60	1000.00	15.00	5.00	1.00	1.00	1.00	0.00	0.55	0.00	8.00
0	10.45	1000.00	15.00	5.00	1.00	1.00	0.00	0.00	0.55	0.00	9.00
1	2.35	1000.00	15.00	5.00	1.00	1.00	1.00	0.00	0.55	0.00	6.00
0	7.00	1000.00	15.00	5.00	1.00	1.00	0.00	0.00	0.55	0.00	2.00
0	1.30	1000.00	15.00	5.00	1.00	1.00	1.00	0.00	0.55	0.00	9.00
0	6.02	1000.00	10.00	7.00	1.00	0.00	0.00	0.00	0.63	0.00	8.00
0	1.85	1000.00	10.00	7.00	1.00	0.00	0.00	0.00	0.63	0.00	2.00
0	2.20	1000.00	10.00	7.00	1.00	1.00	1.00	0.00	0.63	0.00	6.00
0	1.13	1000.00	10.00	7.00	1.00	0.00	1.00	0.00	0.63	0.00	2.00
0	8.20	1000.00	10.00	7.00	1.00	1.00	0.00	0.00	0.63	0.00	9.00
0	5.80	1000.00	10.00	7.00	1.00	0.00	0.00	0.00	0.63	0.00	8.00
0	0.00	1500.00	15.00	5.00	2.00	0.00	0.00	0.00	0.63	0.00	9.00

HC130 21 SEPT 78 TARGETS:42'BOATS

1	9.65	3000.00	8.00	10.00	2.00	0.00	0.00	0.00	0.65	0.00	1.00
1	11.50	2000.00	8.00	11.00	4.00	1.00	0.00	0.00	0.65	0.00	1.00
0	1.40	1000.00	8.00	10.00	2.00	0.00	1.00	0.00	0.71	0.00	1.00
1	0.75	1000.00	8.00	10.00	2.00	0.00	1.00	0.00	0.71	0.00	1.00
1	2.35	1000.00	8.00	10.00	2.00	1.00	1.00	0.00	0.71	0.00	1.00
1	4.10	1000.00	8.00	10.00	2.00	0.00	1.00	0.00	0.71	0.00	1.00
0	7.80	1000.00	8.00	12.00	4.00	1.00	0.00	0.00	0.65	0.00	1.00
1	1.60	1000.00	8.00	12.00	4.00	0.00	1.00	0.00	0.65	0.00	1.00
1	3.60	1000.00	8.00	12.00	4.00	1.00	1.00	0.00	0.65	0.00	1.00
1	5.65	1000.00	8.00	12.00	4.00	0.00	0.00	0.00	0.65	0.00	1.00

HC130 21 SEPT 78 TARGETS: 16'BOATS

1	9.80	5000.00	8.00	10.00	2.00	0.00	0.00	0.00	0.65	0.00	7.00
0	6.00	5000.00	8.00	10.00	2.00	0.00	0.00	0.00	0.65	0.00	2.00
1	9.10	5000.00	8.00	10.00	2.00	0.00	0.00	0.00	0.65	0.00	5.00
0	13.10	5000.00	8.00	10.00	2.00	1.00	0.00	0.00	0.65	0.00	5.00
0	10.25	5000.00	8.00	10.00	2.00	1.00	0.00	0.00	0.65	0.00	2.00
1	9.95	2000.00	8.00	11.00	4.00	0.00	0.00	0.00	0.65	0.00	2.00
0	12.80	2000.00	8.00	11.00	4.00	0.00	0.00	0.00	0.65	0.00	5.00
1	6.10	2000.00	8.00	11.00	4.00	1.00	0.00	0.00	0.65	0.00	5.00
0	6.10	2000.00	8.00	11.00	4.00	1.00	1.00	0.00	0.65	0.00	2.00
0	9.55	2000.00	8.00	11.00	4.00	1.00	0.00	0.00	0.65	0.00	7.00
0	3.00	1000.00	8.00	10.00	2.00	0.00	1.00	0.00	0.71	0.00	5.00
0	4.95	1000.00	8.00	10.00	2.00	0.00	1.00	0.00	0.71	0.00	2.00
0	0.90	1000.00	8.00	10.00	2.00	0.00	1.00	0.00	0.71	0.00	7.00
0	3.10	1000.00	8.00	10.00	2.00	1.00	1.00	0.00	0.71	0.00	2.00
0	1.20	1000.00	8.00	10.00	2.00	1.00	1.00	0.00	0.71	0.00	5.00
0	1.38	1000.00	8.00	10.00	2.00	1.00	1.00	0.00	0.71	0.00	5.00
0	0.90	1000.00	8.00	10.00	2.00	0.00	1.00	0.00	0.71	0.00	2.00
0	3.10	1000.00	8.00	10.00	2.00	1.00	1.00	0.00	0.71	0.00	7.00
0	0.86	1000.00	8.00	10.00	2.00	0.00	1.00	0.00	0.71	0.00	2.00
0	3.10	1000.00	8.00	10.00	2.00	0.00	1.00	0.00	0.71	0.00	5.00
0	11.00	1000.00	8.00	12.00	4.00	1.00	0.00	0.00	0.65	0.00	7.00
0	4.40	1000.00	8.00	12.00	4.00	1.00	1.00	0.00	0.65	0.00	5.00
0	1.88	1000.00	8.00	12.00	4.00	0.00	1.00	0.00	0.65	0.00	5.00
1	8.25	1000.00	8.00	12.00	4.00	0.00	1.00	0.00	0.65	0.00	7.00
0	6.50	1000.00	8.00	12.00	4.00	1.00	1.00	0.00	0.65	0.00	7.00
0	0.00	1000.00	8.00	12.00	4.00	1.00	0.00	0.00	0.65	0.00	5.00
0	1.10	1000.00	8.00	12.00	4.00	0.00	1.00	0.00	0.65	0.00	2.00
0	2.30	1000.00	8.00	12.00	4.00	1.00	1.00	0.00	0.65	0.00	5.00
0	4.17	1000.00	8.00	12.00	4.00	0.00	1.00	0.00	0.65	0.00	7.00

0	2.32	1000.00	8.00	12.00	4.00	1.00	1.00	0.00	0.65	0.00	7.00
0	4.08	1000.00	8.00	12.00	4.00	0.00	1.00	0.00	0.65	0.00	5.00
0	0.72	1000.00	8.00	12.00	4.00	0.00	1.00	0.00	0.65	0.00	2.00
0	2.60	1000.00	8.00	12.00	4.00	1.00	1.00	0.00	0.65	0.00	2.00
0	6.09	1000.00	8.00	12.00	4.00	1.00	0.00	0.00	0.65	0.00	5.00
0	0.30	1000.00	8.00	12.00	4.00	0.00	1.00	0.00	0.65	0.00	7.00
0	1.50	1000.00	8.00	12.00	4.00	0.00	1.00	0.00	0.65	0.00	7.00
0	7.90	1000.00	8.00	12.00	4.00	0.00	1.00	0.00	0.65	0.00	5.00
1	4.50	1000.00	8.00	12.00	4.00	0.00	1.00	0.00	0.65	0.00	2.00
1	3.43	1000.00	8.00	12.00	4.00	1.00	1.00	0.00	0.65	0.00	7.00
0	7.00	1000.00	8.00	12.00	4.00	1.00	1.00	0.00	0.65	0.00	2.00
0	4.98	1000.00	8.00	12.00	4.00	1.00	1.00	0.00	0.65	0.00	5.00
0	2.96	1000.00	8.00	12.00	4.00	0.00	1.00	0.00	0.65	0.00	5.00
0	4.85	1000.00	8.00	12.00	4.00	0.00	1.00	0.00	0.65	0.00	2.00
0	0.90	1000.00	8.00	12.00	4.00	0.00	1.00	0.00	0.65	0.00	7.00
1	1.15	1000.00	8.00	12.00	4.00	0.00	1.00	0.00	0.65	0.00	7.00
0	2.20	1000.00	8.00	12.00	4.00	1.00	1.00	0.00	0.65	0.00	2.00
0	1.00	1000.00	8.00	12.00	4.00	1.00	1.00	0.00	0.65	0.00	5.00
0	1.00	1000.00	8.00	12.00	4.00	1.00	1.00	0.00	0.65	0.00	5.00
0	0.86	1000.00	8.00	12.00	4.00	0.00	1.00	0.00	0.65	0.00	2.00
0	3.05	1000.00	8.00	12.00	4.00	1.00	1.00	0.00	0.65	0.00	7.00
1	5.05	1000.00	8.00	12.00	4.00	0.00	0.00	0.00	0.65	0.00	7.00
0	1.10	1000.00	8.00	12.00	4.00	0.00	1.00	0.00	0.65	0.00	2.00
0	2.67	1000.00	8.00	12.00	4.00	0.00	1.00	0.00	0.65	0.00	5.00
0	0.00	1000.00	8.00	12.00	4.00	0.00	0.00	0.00	0.65	0.00	5.00

HC-130 26 JANUARY 1979 TARGETS:RAFTS

0	4.20	1000.00	10.00	20.00	5.00	1.00	1.00	0.00	1.00	0.00	2.00
0	4.70	1000.00	10.00	20.00	5.00	1.00	1.00	0.00	1.00	0.00	5.00
1	4.10	1000.00	10.00	20.00	5.00	1.00	1.00	0.00	1.00	0.00	5.00
0	11.00	2500.00	10.00	20.00	5.00	0.00	1.00	0.00	1.00	0.00	2.00
0	10.60	2500.00	10.00	20.00	5.00	0.00	1.00	0.00	1.00	0.00	5.00
0	10.90	2500.00	10.00	20.00	5.00	0.00	1.00	0.00	1.00	0.00	5.00
1	5.00	2500.00	10.00	20.00	5.00	1.00	1.00	0.00	1.00	0.00	2.00
0	4.80	2500.00	10.00	20.00	5.00	1.00	1.00	0.00	1.00	0.00	5.00
0	5.00	2500.00	10.00	20.00	5.00	1.00	1.00	0.00	1.00	0.00	5.00
0	5.00	2500.00	10.00	20.00	5.00	0.00	1.00	0.00	0.60	0.00	2.00
0	5.00	2500.00	10.00	20.00	5.00	0.00	1.00	0.00	0.60	0.00	5.00
0	5.00	2500.00	10.00	20.00	5.00	0.00	1.00	0.00	0.60	0.00	5.00
0	10.00	2500.00	10.00	20.00	5.00	1.00	1.00	0.00	0.60	0.00	2.00
0	10.00	2500.00	10.00	20.00	5.00	1.00	1.00	0.00	0.60	0.00	5.00
0	10.00	2500.00	10.00	20.00	5.00	1.00	1.00	0.00	0.60	0.00	5.00
1	7.50	2500.00	10.00	10.00	5.00	0.00	1.00	1.00	0.70	0.00	2.00
0	7.20	2500.00	10.00	10.00	5.00	0.00	1.00	1.00	0.70	0.00	5.00
1	7.10	2500.00	10.00	10.00	5.00	0.00	1.00	1.00	0.70	0.00	5.00
0	11.30	2500.00	10.00	10.00	5.00	0.00	1.00	1.00	0.70	0.00	2.00
0	10.50	2500.00	10.00	10.00	5.00	0.00	1.00	1.00	0.70	0.00	5.00
0	11.20	2500.00	10.00	10.00	5.00	0.00	1.00	1.00	0.70	0.00	5.00

ML-150 27 JANUARY 1979 TARGETS:RAFTS

0	11.00	2500.00	3.50	10.00	1.50	0.00	0.00	0.00	0.90	1.00	2.00
0	11.00	2500.00	3.50	10.00	1.50	0.00	0.00	0.00	0.90	1.00	3.00
0	10.80	2500.00	3.50	10.00	1.50	0.00	0.00	0.00	0.90	1.00	3.00
0	3.00	2500.00	5.00	10.00	1.50	1.00	1.00	0.00	0.90	1.00	2.00
1	9.70	2500.00	5.00	10.00	1.50	0.00	1.00	1.00	0.90	0.00	2.00
0	10.00	2500.00	5.00	10.00	1.50	0.00	1.00	1.00	0.90	0.00	3.00
0	10.10	2500.00	5.00	10.00	1.50	0.00	1.00	1.00	0.90	0.00	3.00
0	2.80	2000.00	6.00	10.00	1.50	1.00	1.00	0.00	0.80	0.00	3.00
0	1.00	2000.00	6.00	10.00	1.50	1.00	1.00	0.00	0.80	0.00	3.00
0	12.20	3000.00	6.00	10.00	1.50	1.00	0.00	0.00	0.80	0.00	2.00
0	9.40	3000.00	6.00	10.00	1.50	1.00	0.00	0.00	0.80	0.00	3.00
0	10.80	3000.00	6.00	10.00	1.50	1.00	0.00	0.00	0.80	0.00	3.00
0	8.80	3000.00	6.00	10.00	1.50	1.00	0.00	0.00	0.80	0.00	2.00
1	4.70	3000.00	6.00	10.00	1.50	1.00	0.00	0.00	0.80	0.00	3.00
1	5.80	3000.00	6.00	10.00	1.50	1.00	0.00	0.00	0.80	0.00	3.00
0	9.10	4100.00	6.00	10.00	1.50	1.00	1.00	0.00	0.80	0.00	3.00
0	4.50	4100.00	6.00	10.00	1.50	1.00	0.00	0.00	0.80	0.00	2.00
0	2.60	4100.00	6.00	10.00	1.50	1.00	0.00	0.00	0.80	0.00	3.00
0	2.90	4100.00	6.00	10.00	1.50	1.00	0.00	0.00	0.80	0.00	3.00
0	5.20	5000.00	6.00	10.00	1.50	1.00	1.00	0.00	0.80	0.00	2.00
0	1.80	5000.00	6.00	10.00	1.50	1.00	1.00	0.00	0.80	0.00	3.00
0	3.20	5000.00	6.00	10.00	1.50	1.00	1.00	0.00	0.80	0.00	3.00
0	4.00	5000.00	6.00	10.00	1.50	1.00	1.00	0.00	0.80	0.00	3.00
0	2.50	5000.00	6.00	10.00	1.50	1.00	1.00	0.00	0.80	0.00	3.00

HC-130 31 JANUARY 1979 TARGETS:RAFTS

0	3.70	500.00	10.00	50.00	5.00	0.00	1.00	0.00	0.80	0.00	2.00
0	4.10	500.00	10.00	50.00	5.00	0.00	1.00	0.00	0.80	0.00	5.00
0	4.20	500.00	10.00	50.00	5.00	0.00	1.00	0.00	0.80	0.00	5.00
0	1.90	500.00	10.00	50.00	5.00	1.00	1.00	0.00	0.80	0.00	2.00
0	2.90	500.00	10.00	50.00	5.00	1.00	1.00	0.00	0.80	0.00	5.00
0	3.00	500.00	10.00	50.00	5.00	1.00	1.00	0.00	0.80	0.00	5.00
0	0.10	500.00	10.00	50.00	5.00	0.00	1.00	0.00	0.80	0.00	2.00
0	0.70	500.00	10.00	50.00	5.00	0.00	1.00	0.00	0.80	0.00	5.00
0	0.60	500.00	10.00	50.00	5.00	0.00	1.00	0.00	0.80	0.00	5.00
0	2.00	500.00	10.00	50.00	5.00	0.00	1.00	0.00	0.80	0.00	2.00
0	0.60	500.00	10.00	50.00	5.00	0.00	1.00	0.00	0.80	0.00	5.00
0	0.40	500.00	10.00	50.00	5.00	0.00	1.00	0.00	0.80	0.00	5.00
0	3.20	500.00	10.00	50.00	5.00	0.00	1.00	0.00	0.80	0.00	2.00
0	2.40	500.00	10.00	50.00	5.00	0.00	1.00	0.00	0.80	0.00	5.00
0	2.20	500.00	10.00	50.00	5.00	0.00	1.00	0.00	0.80	0.00	5.00
0	10.00	2500.00	0.00	50.00	5.00	0.00	1.00	0.00	0.80	1.00	2.00
0	9.60	2500.00	0.00	50.00	5.00	0.00	1.00	0.00	0.80	1.00	5.00
0	9.70	2500.00	0.00	50.00	5.00	0.00	1.00	0.00	0.80	1.00	5.00
0	4.90	2500.00	0.00	50.00	5.00	1.00	0.00	0.00	0.80	1.00	2.00
0	3.90	2500.00	0.00	50.00	5.00	1.00	0.00	0.00	0.80	1.00	5.00
0	3.60	2500.00	0.00	50.00	5.00	1.00	0.00	0.00	0.80	1.00	5.00
0	0.50	2500.00	0.00	50.00	5.00	1.00	1.00	0.00	0.80	1.00	2.00
0	0.50	2500.00	0.00	50.00	5.00	1.00	1.00	0.00	0.80	1.00	5.00
0	0.50	2500.00	0.00	50.00	5.00	1.00	1.00	0.00	0.80	1.00	5.00
0	8.40	2500.00	0.00	50.00	5.00	0.00	1.00	0.00	0.80	1.00	2.00
0	8.40	2500.00	0.00	50.00	5.00	0.00	1.00	0.00	0.80	1.00	5.00
0	8.80	2500.00	0.00	50.00	5.00	0.00	1.00	0.00	0.80	1.00	5.00
0	12.50	2500.00	0.00	50.00	5.00	1.00	1.00	0.00	0.80	1.00	2.00
0	12.50	2500.00	0.00	50.00	5.00	1.00	1.00	0.00	0.80	1.00	5.00

HC130 2 OCT 79 TARGET5:41'UTB

1	28.20	2000.00	15.00	4.00	0.00	0.00	0.00	5.00	0.81	0.00	2.00
1	34.00	2000.00	15.00	4.00	0.00	0.00	0.00	5.00	0.81	0.00	2.00
1	8.90	3000.00	15.00	4.00	0.00	0.00	0.00	6.00	0.81	0.00	2.00
1	14.80	3000.00	15.00	4.00	0.00	0.00	0.00	6.00	0.81	0.00	2.00
1	21.10	3000.00	15.00	4.00	0.00	0.00	0.00	6.00	0.81	0.00	2.00
1	28.10	3000.00	15.00	4.00	0.00	0.00	0.00	6.00	0.81	0.00	2.00
1	34.20	3000.00	15.00	4.00	0.00	0.00	0.00	6.00	0.81	0.00	2.00
1	6.50	5000.00	15.00	4.00	0.00	0.00	0.00	6.00	0.81	0.00	2.00
1	12.50	5000.00	15.00	4.00	0.00	0.00	0.00	6.00	0.81	0.00	2.00
1	18.20	5000.00	15.00	4.00	0.00	0.00	0.00	6.00	0.81	0.00	2.00
1	24.60	5000.00	15.00	7.00	1.00	0.00	0.00	6.00	0.81	0.00	2.00
1	30.40	5000.00	15.00	7.00	1.00	0.00	0.00	7.00	0.81	0.00	2.00
1	35.30	5000.00	15.00	7.00	1.00	0.00	0.00	7.00	0.81	0.00	2.00
1	5.70	7500.00	15.00	7.00	1.00	0.00	1.00	7.00	0.81	0.00	2.00
1	4.70	7500.00	15.00	7.00	1.00	0.00	1.00	7.00	0.81	0.00	2.00
1	12.30	7500.00	15.00	7.00	1.00	0.00	0.00	7.00	0.81	0.00	2.00
1	19.60	7500.00	15.00	7.00	1.00	0.00	0.00	7.00	0.81	0.00	2.00
1	27.40	7500.00	15.00	7.00	1.00	0.00	0.00	7.00	0.81	0.00	2.00

HC130 2 OCT 79 TARGETS:RAFTS

1	3.50	2000.00	15.00	4.00	0.00	0.00	0.00	5.00	0.81	0.00	1.00
1	3.70	2000.00	15.00	4.00	0.00	0.00	0.00	5.00	0.81	0.00	3.00
1	9.90	2000.00	15.00	4.00	0.00	0.00	0.00	5.00	0.81	0.00	1.00
1	8.50	2000.00	15.00	4.00	0.00	0.00	0.00	5.00	0.81	0.00	3.00
0	21.90	2000.00	15.00	4.00	0.00	0.00	1.00	5.00	0.81	0.00	1.00
0	28.70	2000.00	15.00	4.00	0.00	0.00	0.00	5.00	0.81	0.00	1.00
0	27.30	2000.00	15.00	4.00	0.00	0.00	0.00	5.00	0.81	0.00	3.00
0	26.30	2000.00	15.00	4.00	0.00	0.00	0.00	5.00	0.81	0.00	2.00
0	34.50	2000.00	15.00	4.00	0.00	0.00	0.00	5.00	0.81	0.00	1.00
0	33.10	2000.00	15.00	4.00	0.00	0.00	0.00	5.00	0.81	0.00	3.00
1	9.00	3000.00	15.00	4.00	0.00	0.00	0.00	6.00	0.81	0.00	3.00
1	7.90	3000.00	15.00	4.00	0.00	0.00	0.00	6.00	0.81	0.00	2.00
0	16.50	3000.00	15.00	4.00	0.00	0.00	0.00	6.00	0.81	0.00	1.00
1	14.80	3000.00	15.00	4.00	0.00	0.00	0.00	6.00	0.81	0.00	3.00
1	13.80	3000.00	15.00	4.00	0.00	0.00	0.00	6.00	0.81	0.00	2.00
0	22.20	3000.00	15.00	4.00	0.00	0.00	0.00	6.00	0.81	0.00	1.00
0	20.90	3000.00	15.00	4.00	0.00	0.00	0.00	6.00	0.81	0.00	3.00
0	20.10	3000.00	15.00	4.00	0.00	0.00	0.00	6.00	0.81	0.00	2.00
0	28.60	3000.00	15.00	4.00	0.00	0.00	0.00	6.00	0.81	0.00	1.00
0	27.60	3000.00	15.00	4.00	0.00	0.00	0.00	6.00	0.81	0.00	3.00
0	26.70	3000.00	15.00	4.00	0.00	0.00	0.00	6.00	0.81	0.00	2.00
0	33.60	3000.00	15.00	4.00	0.00	0.00	0.00	6.00	0.81	0.00	3.00
0	32.90	3000.00	15.00	4.00	0.00	0.00	0.00	6.00	0.81	0.00	2.00
0	3.90	3000.00	15.00	4.00	0.00	0.00	1.00	6.00	0.81	0.00	1.00

1	2.60	5000.00	15.00	4.00	0.00	0.00	1.00	6.00	0.81	0.00	3.00
0	10.30	5000.00	15.00	4.00	0.00	0.00	1.00	6.00	0.81	0.00	1.00
1	8.90	5000.00	15.00	4.00	0.00	0.00	0.00	6.00	0.81	0.00	3.00
0	15.90	5000.00	15.00	7.00	1.00	0.00	0.00	6.00	0.81	0.00	1.00
1	14.70	5000.00	15.00	7.00	1.00	0.00	0.00	6.00	0.81	0.00	3.00
0	22.20	5000.00	15.00	7.00	1.00	0.00	0.00	6.00	0.81	0.00	1.00
0	28.70	5000.00	15.00	7.00	1.00	0.00	0.00	7.00	0.81	0.00	1.00
0	27.30	5000.00	15.00	7.00	1.00	0.00	0.00	7.00	0.81	0.00	3.00
0	35.00	5000.00	15.00	7.00	1.00	0.00	0.00	7.00	0.81	0.00	1.00
0	33.50	5000.00	15.00	7.00	1.00	0.00	0.00	7.00	0.81	0.00	3.00
0	4.50	7500.00	15.00	7.00	1.00	0.00	1.00	7.00	0.81	0.00	2.00
0	7.70	7500.00	15.00	7.00	1.00	0.00	1.00	7.00	0.81	0.00	1.00
0	8.90	7500.00	15.00	7.00	1.00	0.00	0.00	7.00	0.81	0.00	3.00
0	7.80	7500.00	15.00	7.00	1.00	0.00	1.00	7.00	0.81	0.00	2.00
0	14.20	7500.00	15.00	7.00	1.00	0.00	0.00	7.00	0.81	0.00	3.00
0	20.50	7500.00	15.00	7.00	1.00	0.00	0.00	7.00	0.81	0.00	3.00
0	27.40	7500.00	15.00	7.00	1.00	0.00	0.00	7.00	0.81	0.00	3.00
0	26.60	7500.00	15.00	7.00	1.00	0.00	0.00	7.00	0.81	0.00	2.00
0	33.30	7500.00	15.00	7.00	1.00	0.00	0.00	7.00	0.81	0.00	3.00
0	32.50	7500.00	15.00	7.00	1.00	0.00	0.00	7.00	0.81	0.00	2.00

HC130 3 OCT 79 TARGETS:41'BOATS

0	5.50	5000.00	4.00	16.00	2.00	0.00	1.00	4.00	0.95	1.00	2.00
1	1.90	5000.00	4.00	16.00	2.00	0.00	1.00	4.00	0.95	1.00	2.00
1	8.80	5000.00	4.00	16.00	2.00	0.00	1.00	5.00	0.95	1.00	2.00
1	14.90	5000.00	4.00	16.00	2.00	0.00	0.00	5.00	0.95	1.00	2.00
1	20.90	5000.00	4.00	16.00	2.00	0.00	0.00	6.00	0.95	1.00	2.00
1	27.10	5000.00	4.00	16.00	2.00	0.00	0.00	6.00	0.95	1.00	2.00
1	33.00	5000.00	4.00	16.00	2.00	0.00	0.00	6.00	0.95	1.00	2.00
1	9.00	5000.00	4.00	16.00	2.00	0.00	1.00	4.00	1.00	1.00	2.00
1	4.00	5000.00	4.00	16.00	2.00	0.00	0.00	4.00	1.00	1.00	2.00
1	2.20	5000.00	4.00	16.00	3.00	0.00	0.00	4.00	1.00	1.00	2.00
1	7.90	5000.00	4.00	16.00	3.00	0.00	1.00	5.00	1.00	1.00	2.00
1	13.40	5000.00	4.00	16.00	3.00	0.00	0.00	5.00	1.00	1.00	2.00
1	20.10	5000.00	4.00	16.00	3.00	0.00	0.00	5.00	1.00	1.00	2.00
1	6.80	5000.00	3.00	16.00	3.00	0.00	1.00	5.00	1.00	1.00	2.00
1	9.20	5000.00	3.00	16.00	3.00	0.00	1.00	6.00	1.00	1.00	2.00
1	20.90	5000.00	3.00	16.00	3.00	0.00	0.00	6.00	1.00	1.00	2.00
1	26.90	5000.00	3.00	16.00	3.00	0.00	0.00	7.00	1.00	1.00	2.00

HC130 3 OCT 79 TARGETS: 16'BOATS

0	3.80	2000.00	4.00	10.00	1.00	0.00	1.00	4.00	1.00	1.00	4.00
0	2.70	2000.00	4.00	10.00	1.00	0.00	1.00	4.00	1.00	1.00	4.00
0	13.50	2000.00	4.00	10.00	1.00	0.00	1.00	4.00	1.00	1.00	2.00
0	8.60	2000.00	4.00	10.00	1.00	0.00	1.00	4.00	1.00	1.00	4.00
0	19.20	2000.00	4.00	10.00	1.00	0.00	0.00	4.00	1.00	1.00	2.00
0	14.70	2000.00	4.00	10.00	1.00	0.00	0.00	4.00	1.00	1.00	4.00
0	21.20	2000.00	4.00	10.00	1.00	0.00	0.00	5.00	1.00	1.00	4.00
0	31.70	2000.00	4.00	10.00	1.00	0.00	0.00	5.00	1.00	1.00	2.00
0	5.20	3000.00	4.00	16.00	2.00	0.00	1.00	4.00	0.95	1.00	2.00
0	10.00	3000.00	4.00	16.00	2.00	0.00	1.00	4.00	0.95	1.00	4.00
1	1.10	3000.00	4.00	16.00	2.00	0.00	1.00	4.00	0.95	1.00	2.00
1	3.60	3000.00	4.00	16.00	2.00	0.00	1.00	4.00	0.95	1.00	4.00
0	7.00	3000.00	4.00	16.00	2.00	0.00	1.00	5.00	0.95	1.00	2.00
1	2.40	3000.00	4.00	16.00	2.00	0.00	1.00	5.00	0.95	1.00	4.00
1	18.20	3000.00	4.00	16.00	2.00	0.00	1.00	6.00	0.95	1.00	2.00
1	13.80	3000.00	4.00	16.00	2.00	0.00	1.00	6.00	0.95	1.00	4.00
0	25.60	3000.00	4.00	16.00	2.00	0.00	0.00	6.00	0.95	1.00	2.00
0	20.90	3000.00	4.00	16.00	2.00	0.00	0.00	6.00	1.00	1.00	4.00
0	27.30	3000.00	4.00	16.00	2.00	0.00	0.00	6.00	1.00	1.00	4.00
0	5.00	5000.00	4.00	16.00	2.00	0.00	1.00	4.00	1.00	1.00	2.00

0	9.60	5000.00	4.00	16.00	2.00	0.00	1.00	4.00	1.00	1.00	4.00
0	13.10	5000.00	4.00	16.00	5.00	0.00	0.00	5.00	1.00	1.00	2.00
0	18.80	5000.00	4.00	16.00	5.00	0.00	0.00	5.00	1.00	1.00	2.00
1	14.20	5000.00	4.00	16.00	5.00	0.00	0.00	5.00	1.00	1.00	4.00
0	21.80	5000.00	4.00	16.00	5.00	0.00	0.00	5.00	1.00	1.00	4.00
0	21.50	5000.00	4.00	16.00	5.00	0.00	0.00	5.00	1.00	1.00	6.00
0	31.70	5000.00	4.00	16.00	5.00	0.00	1.00	6.00	1.00	1.00	2.00
0	27.20	5000.00	4.00	16.00	5.00	0.00	0.00	6.00	1.00	1.00	4.00
0	26.90	5000.00	4.00	16.00	5.00	0.00	1.00	6.00	1.00	1.00	6.00
0	10.90	5000.00	5.00	16.00	5.00	0.00	1.00	5.00	1.00	1.00	6.00
0	4.20	5000.00	5.00	16.00	5.00	0.00	1.00	5.00	1.00	1.00	6.00
0	6.60	5000.00	5.00	16.00	5.00	0.00	0.00	5.00	1.00	1.00	2.00
0	18.80	5000.00	5.00	16.00	5.00	0.00	0.00	6.00	1.00	1.00	2.00
0	13.80	5000.00	5.00	16.00	5.00	0.00	0.00	6.00	1.00	1.00	6.00
0	25.60	5000.00	5.00	16.00	5.00	0.00	0.00	6.00	1.00	1.00	2.00
0	20.70	5000.00	5.00	16.00	5.00	0.00	0.00	6.00	1.00	1.00	6.00
0	31.80	5000.00	5.00	16.00	5.00	0.00	1.00	7.00	1.00	1.00	2.00
0	27.30	5000.00	5.00	16.00	5.00	0.00	1.00	7.00	1.00	1.00	4.00
0	26.70	5000.00	5.00	16.00	5.00	0.00	1.00	7.00	1.00	1.00	6.00

HC130 4 OCT 79 TARGETS:CUTTERS (82'/95')

1	4.20	2000.00	6.00	7.00	5.00	0.00	1.00	4.00	0.89	0.00	5.00
1	2.00	2000.00	6.00	7.00	5.00	0.00	1.00	4.00	0.89	0.00	5.00
1	7.90	2000.00	6.00	7.00	5.00	0.00	0.00	4.00	0.89	0.00	5.00
1	15.80	2000.00	6.00	7.00	5.00	0.00	0.00	4.00	0.89	0.00	5.00
1	19.20	2000.00	6.00	7.00	5.00	0.00	0.00	4.00	0.89	0.00	5.00
1	25.60	2000.00	6.00	9.00	5.00	0.00	0.00	5.00	0.89	0.00	5.00
1	29.40	2000.00	6.00	9.00	5.00	0.00	0.00	5.00	0.89	0.00	5.00
1	10.40	5000.00	6.00	8.00	5.00	0.00	0.00	4.00	0.84	0.00	5.00
1	3.50	5000.00	6.00	8.00	5.00	0.00	0.00	4.00	0.84	0.00	5.00
1	4.50	5000.00	6.00	8.00	5.00	0.00	0.00	5.00	0.84	0.00	5.00
1	10.50	5000.00	6.00	8.00	5.00	0.00	0.00	5.00	0.84	0.00	5.00
1	16.60	5000.00	6.00	8.00	5.00	0.00	0.00	6.00	0.84	0.00	5.00
1	25.60	5000.00	6.00	8.00	5.00	0.00	0.00	6.00	0.84	0.00	5.00
1	30.00	5000.00	6.00	8.00	5.00	0.00	0.00	6.00	0.84	0.00	5.00
1	11.20	5000.00	6.00	8.00	5.00	0.00	0.00	5.00	0.84	0.00	5.00
1	5.10	5000.00	6.00	8.00	5.00	0.00	0.00	5.00	0.84	0.00	5.00
1	1.50	5000.00	6.00	8.00	5.00	0.00	1.00	5.00	0.84	0.00	5.00
1	7.50	5000.00	6.00	8.00	5.00	0.00	0.00	5.00	0.84	0.00	5.00
1	15.20	5000.00	6.00	8.00	5.00	0.00	0.00	5.00	0.84	0.00	5.00
1	29.20	5000.00	6.00	5.00	5.00	0.00	0.00	7.00	0.84	0.00	5.00
1	15.90	5000.00	6.00	5.00	5.00	0.00	0.00	6.00	0.84	0.00	5.00
1	10.50	5000.00	6.00	5.00	5.00	0.00	0.00	6.00	0.84	0.00	5.00
1	3.80	5000.00	6.00	5.00	5.00	0.00	1.00	6.00	0.84	0.00	5.00
1	11.80	5000.00	6.00	5.00	5.00	0.00	0.00	6.00	0.84	0.00	5.00
1	9.90	5000.00	6.00	5.00	5.00	0.00	0.00	5.00	0.84	0.00	5.00
1	7.60	5000.00	6.00	4.00	2.00	0.00	0.00	5.00	0.81	0.00	5.00
1	7.80	5000.00	6.00	4.00	2.00	0.00	0.00	5.00	0.81	0.00	5.00
1	10.50	5000.00	6.00	4.00	2.00	0.00	0.00	4.00	0.81	0.00	5.00
1	12.40	5000.00	6.00	4.00	2.00	0.00	0.00	4.00	0.81	0.00	5.00
1	6.10	5000.00	6.00	4.00	2.00	0.00	0.00	4.00	0.81	0.00	5.00
1	6.90	5000.00	6.00	4.00	2.00	0.00	0.00	5.00	0.81	0.00	5.00
1	11.90	5000.00	6.00	4.00	2.00	0.00	0.00	5.00	0.81	0.00	5.00
1	11.50	5000.00	6.00	4.00	2.00	0.00	0.00	5.00	0.81	0.00	5.00
1	11.10	5000.00	6.00	4.00	2.00	0.00	0.00	5.00	0.81	0.00	5.00

HC150 4 OCT 79 TARGETS:41'/44' BOATS

1	10.60	2000.00	6.00	7.00	5.00	0.00	1.00	4.00	0.89	0.00	2.00
1	8.80	2000.00	6.00	7.00	5.00	0.00	1.00	4.00	0.89	0.00	5.00
1	2.50	2000.00	6.00	7.00	5.00	0.00	0.00	4.00	0.89	0.00	2.00
1	6.10	2000.00	6.00	7.00	5.00	0.00	0.00	4.00	0.89	0.00	5.00
1	9.90	2000.00	6.00	7.00	5.00	0.00	0.00	4.00	0.89	0.00	2.00
1	13.70	2000.00	6.00	7.00	5.00	0.00	0.00	4.00	0.89	0.00	5.00
1	16.90	2000.00	6.00	7.00	5.00	0.00	0.00	4.00	0.89	0.00	2.00
1	20.90	2000.00	6.00	7.00	5.00	0.00	0.00	4.00	0.89	0.00	5.00
1	24.50	2000.00	6.00	7.00	5.00	0.00	0.00	5.00	0.89	0.00	2.00
1	29.20	2000.00	6.00	7.00	5.00	0.00	0.00	5.00	0.89	0.00	5.00
1	31.00	2000.00	6.00	7.00	5.00	0.00	0.00	5.00	0.89	0.00	2.00
1	35.70	2000.00	6.00	7.00	5.00	0.00	0.00	5.00	0.89	0.00	5.00
1	5.50	5000.00	6.00	8.00	5.00	0.00	1.00	4.00	0.84	0.00	2.00
1	8.20	5000.00	6.00	8.00	5.00	0.00	1.00	4.00	0.84	0.00	5.00
1	6.80	5000.00	6.00	8.00	5.00	0.00	0.00	5.00	0.84	0.00	2.00
1	6.60	5000.00	6.00	8.00	5.00	0.00	0.00	5.00	0.84	0.00	5.00
1	12.80	5000.00	6.00	8.00	5.00	0.00	0.00	5.00	0.84	0.00	2.00
1	13.60	5000.00	6.00	8.00	5.00	0.00	0.00	5.00	0.84	0.00	5.00
1	16.70	5000.00	6.00	8.00	5.00	0.00	0.00	6.00	0.84	0.00	2.00
1	21.20	5000.00	6.00	8.00	5.00	0.00	0.00	6.00	0.84	0.00	5.00
1	25.40	5000.00	6.00	8.00	5.00	0.00	0.00	6.00	0.84	0.00	2.00
1	29.00	5000.00	6.00	8.00	5.00	0.00	0.00	6.00	0.84	0.00	5.00
1	31.00	5000.00	6.00	8.00	5.00	0.00	0.00	6.00	0.84	0.00	2.00
1	5.80	5000.00	6.00	8.00	5.00	0.00	0.00	5.00	0.84	0.00	2.00
1	10.40	5000.00	6.00	8.00	5.00	0.00	0.00	5.00	0.84	0.00	5.00
1	4.70	5000.00	6.00	8.00	5.00	0.00	0.00	5.00	0.84	0.00	5.00
1	6.60	5000.00	6.00	8.00	5.00	0.00	0.00	5.00	0.84	0.00	2.00

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1	1.60	5000.00	6.00	8.00	5.00	0.00	0.00	5.00	0.84	0.00	5.00
1	12.50	5000.00	6.00	8.00	5.00	0.00	0.00	5.00	0.84	0.00	2.00
1	8.00	5000.00	6.00	8.00	5.00	0.00	0.00	5.00	0.84	0.00	5.00
1	18.50	5000.00	6.00	8.00	5.00	0.00	0.00	5.00	0.84	0.00	2.00
1	15.50	5000.00	6.00	8.00	5.00	0.00	0.00	5.00	0.84	0.00	5.00
1	25.20	5000.00	6.00	5.00	5.00	0.00	0.00	6.00	0.80	0.00	2.00
1	25.00	5000.00	6.00	5.00	5.00	0.00	0.00	6.00	0.80	0.00	5.00
1	30.20	5000.00	6.00	5.00	5.00	0.00	0.00	7.00	0.80	0.00	5.00
1	12.80	5000.00	6.00	5.00	5.00	0.00	0.00	6.00	0.80	0.00	2.00
1	10.20	5000.00	6.00	5.00	5.00	0.00	0.00	6.00	0.80	0.00	5.00
1	7.40	5000.00	6.00	5.00	5.00	0.00	0.00	6.00	0.80	0.00	2.00
1	8.80	5000.00	6.00	5.00	5.00	0.00	0.00	6.00	0.80	0.00	2.00
1	15.30	5000.00	6.00	5.00	5.00	0.00	0.00	6.00	0.80	0.00	5.00
1	9.80	5000.00	6.00	5.00	5.00	0.00	0.00	5.00	0.80	0.00	5.00
1	11.80	5000.00	6.00	5.00	5.00	0.00	0.00	5.00	0.80	0.00	2.00
1	4.10	5000.00	6.00	5.00	5.00	0.00	0.00	5.00	0.80	0.00	5.00
1	7.10	5000.00	6.00	4.00	2.00	0.00	0.00	5.00	0.81	0.00	2.00
1	11.10	5000.00	6.00	4.00	2.00	0.00	0.00	5.00	0.81	0.00	5.00
1	15.40	5000.00	6.00	4.00	2.00	0.00	0.00	5.00	0.81	0.00	5.00
1	13.20	5000.00	6.00	4.00	2.00	0.00	0.00	4.00	0.81	0.00	2.00
1	14.30	5000.00	6.00	4.00	2.00	0.00	0.00	4.00	0.81	0.00	5.00
1	7.90	5000.00	6.00	4.00	2.00	0.00	0.00	4.00	0.81	0.00	2.00
1	10.40	5000.00	6.00	4.00	2.00	0.00	0.00	4.00	0.81	0.00	5.00
1	13.60	5000.00	6.00	4.00	2.00	0.00	0.00	5.00	0.81	0.00	2.00
1	4.20	5000.00	6.00	4.00	2.00	0.00	0.00	5.00	0.81	0.00	5.00
1	12.80	5000.00	6.00	4.00	2.00	0.00	0.00	5.00	0.81	0.00	2.00
1	6.40	5000.00	6.00	4.00	2.00	0.00	0.00	5.00	0.81	0.00	2.00
1	7.90	5000.00	6.00	4.00	2.00	0.00	0.00	5.00	0.81	0.00	2.00
1	9.40	5000.00	6.00	4.00	2.00	0.00	0.00	5.00	0.81	0.00	5.00

HC130 4 OCT 79 TARGETS: 16'BOATS

0	3.60	2000.00	6.00	7.00	3.00	0.00	1.00	4.00	0.89	0.00	3.00
0	5.50	2000.00	6.00	7.00	3.00	0.00	1.00	4.00	0.89	0.00	2.00
1	2.50	2000.00	6.00	7.00	3.00	0.00	1.00	4.00	0.89	0.00	3.00
1	4.50	2000.00	6.00	7.00	3.00	0.00	1.00	4.00	0.89	0.00	4.00
0	3.20	2000.00	6.00	7.00	3.00	0.00	1.00	4.00	0.89	0.00	1.00
0	4.70	2000.00	6.00	7.00	3.00	0.00	1.00	4.00	0.89	0.00	6.00
1	8.60	2000.00	6.00	7.00	3.00	0.00	0.00	4.00	0.89	0.00	3.00
0	6.60	2000.00	6.00	7.00	3.00	0.00	1.00	4.00	0.89	0.00	2.00
0	10.90	2000.00	6.00	7.00	3.00	0.00	0.00	4.00	0.89	0.00	4.00
1	3.20	2000.00	6.00	7.00	3.00	0.00	1.00	4.00	0.89	0.00	1.00
1	14.60	2000.00	6.00	7.00	3.00	0.00	0.00	4.00	0.89	0.00	3.00
0	12.30	2000.00	6.00	7.00	3.00	0.00	0.00	4.00	0.89	0.00	2.00
0	16.90	2000.00	6.00	7.00	3.00	0.00	0.00	4.00	0.89	0.00	4.00
0	9.10	2000.00	6.00	7.00	3.00	0.00	1.00	4.00	0.89	0.00	1.00
0	19.80	2000.00	6.00	7.00	3.00	0.00	0.00	4.00	0.89	0.00	3.00
0	18.50	2000.00	6.00	7.00	3.00	0.00	0.00	4.00	0.89	0.00	2.00
1	22.20	2000.00	6.00	7.00	3.00	0.00	0.00	4.00	0.89	0.00	4.00
0	15.00	2000.00	6.00	7.00	3.00	0.00	0.00	4.00	0.89	0.00	1.00
0	13.60	2000.00	6.00	7.00	3.00	0.00	0.00	4.00	0.89	0.00	6.00
0	26.50	2000.00	6.00	7.00	3.00	0.00	0.00	5.00	0.89	0.00	3.00
0	29.20	2000.00	6.00	7.00	3.00	0.00	0.00	5.00	0.89	0.00	4.00
0	21.60	2000.00	6.00	7.00	3.00	0.00	0.00	5.00	0.89	0.00	1.00
0	20.40	2000.00	6.00	7.00	3.00	0.00	1.00	5.00	0.89	0.00	6.00
0	33.50	2000.00	6.00	9.00	3.00	0.00	0.00	5.00	0.89	0.00	3.00
0	35.40	2000.00	6.00	9.00	3.00	0.00	0.00	5.00	0.89	0.00	4.00
0	27.70	2000.00	6.00	9.00	3.00	0.00	0.00	5.00	0.89	0.00	1.00
0	26.40	2000.00	6.00	9.00	3.00	0.00	0.00	5.00	0.89	0.00	6.00
0	3.80	3000.00	6.00	8.00	3.00	0.00	1.00	4.00	0.84	0.00	3.00
0	5.90	3000.00	6.00	8.00	3.00	0.00	1.00	4.00	0.84	0.00	2.00
0	1.60	3000.00	6.00	8.00	3.00	0.00	1.00	4.00	0.84	0.00	4.00
0	10.70	3000.00	6.00	8.00	3.00	0.00	1.00	4.00	0.84	0.00	6.00

1	2.60	5000.00	6.00	8.00	5.00	0.00	0.00	4.00	0.84	0.00	5.00
1	8.60	5000.00	6.00	8.00	5.00	0.00	1.00	5.00	0.84	0.00	5.00
1	6.40	5000.00	6.00	8.00	5.00	0.00	0.00	5.00	0.84	0.00	2.00
0	10.60	5000.00	6.00	8.00	5.00	0.00	1.00	5.00	0.84	0.00	4.00
1	5.00	5000.00	6.00	8.00	5.00	0.00	1.00	5.00	0.84	0.00	1.00
0	1.50	5000.00	6.00	8.00	5.00	0.00	1.00	5.00	0.84	0.00	6.00
1	14.60	5000.00	6.00	8.00	5.00	0.00	0.00	5.00	0.84	0.00	5.00
0	12.50	5000.00	6.00	8.00	5.00	0.00	0.00	5.00	0.84	0.00	2.00
1	17.00	5000.00	6.00	8.00	5.00	0.00	0.00	5.00	0.84	0.00	4.00
1	9.20	5000.00	6.00	8.00	5.00	0.00	0.00	5.00	0.84	0.00	1.00
0	7.50	5000.00	6.00	8.00	5.00	0.00	0.00	5.00	0.84	0.00	6.00
0	20.70	5000.00	6.00	8.00	5.00	0.00	0.00	6.00	0.84	0.00	5.00
0	22.90	5000.00	6.00	8.00	5.00	0.00	0.00	6.00	0.84	0.00	4.00
1	15.10	5000.00	6.00	8.00	5.00	0.00	0.00	6.00	0.84	0.00	1.00
1	15.60	5000.00	6.00	8.00	5.00	0.00	0.00	6.00	0.84	0.00	6.00
0	27.50	5000.00	6.00	8.00	5.00	0.00	0.00	6.00	0.84	0.00	5.00
0	25.40	5000.00	6.00	8.00	5.00	0.00	0.00	6.00	0.84	0.00	2.00
0	29.80	5000.00	6.00	8.00	5.00	0.00	0.00	6.00	0.84	0.00	4.00
0	21.90	5000.00	6.00	8.00	5.00	0.00	0.00	6.00	0.84	0.00	1.00
0	20.40	5000.00	6.00	8.00	5.00	0.00	0.00	6.00	0.84	0.00	6.00
0	35.20	5000.00	6.00	8.00	5.00	0.00	0.00	6.00	0.84	0.00	4.00
0	27.50	5000.00	6.00	8.00	5.00	0.00	0.00	6.00	0.84	0.00	1.00
1	4.00	5000.00	6.00	8.00	5.00	0.00	0.00	5.00	0.84	0.00	5.00
0	6.40	5000.00	6.00	8.00	5.00	0.00	0.00	5.00	0.84	0.00	2.00
1	9.70	5000.00	6.00	8.00	5.00	0.00	0.00	5.00	0.84	0.00	1.00
1	11.20	5000.00	6.00	8.00	5.00	0.00	0.00	5.00	0.84	0.00	6.00
1	2.20	5000.00	6.00	8.00	5.00	0.00	0.00	5.00	0.84	0.00	5.00
0	5.90	5000.00	6.00	8.00	5.00	0.00	0.00	5.00	0.84	0.00	4.00
1	5.80	5000.00	6.00	8.00	5.00	0.00	0.00	5.00	0.84	0.00	1.00
1	5.50	5000.00	6.00	8.00	5.00	0.00	0.00	5.00	0.84	0.00	6.00
0	5.70	5000.00	6.00	8.00	5.00	0.00	0.00	5.00	0.84	0.00	2.00

1	2.60	5000.00	6.00	8.00	3.00	0.00	1.00	5.00	0.84	0.00	1.00
1	14.20	5000.00	6.00	8.00	3.00	0.00	0.00	5.00	0.84	0.00	3.00
1	15.80	5000.00	6.00	8.00	3.00	0.00	0.00	5.00	0.84	0.00	4.00
0	6.90	5000.00	6.00	8.00	3.00	0.00	0.00	5.00	0.84	0.00	6.00
1	17.70	5000.00	6.00	8.00	3.00	0.00	0.00	5.00	0.84	0.00	2.00
0	14.40	5000.00	6.00	8.00	3.00	0.00	0.00	5.00	0.84	0.00	1.00
0	13.00	5000.00	6.00	8.00	3.00	0.00	0.00	5.00	0.84	0.00	6.00
0	27.40	5000.00	6.00	8.00	3.00	0.00	0.00	6.00	0.80	0.00	3.00
0	29.00	5000.00	6.00	5.00	3.00	0.00	0.00	6.00	0.80	0.00	4.00
0	21.50	5000.00	6.00	5.00	3.00	0.00	0.00	6.00	0.80	0.00	1.00
0	20.00	5000.00	6.00	5.00	3.00	0.00	0.00	6.00	0.80	0.00	6.00
0	32.70	5000.00	6.00	5.00	3.00	0.00	1.00	7.00	0.80	0.00	5.00
0	30.40	5000.00	6.00	5.00	3.00	0.00	0.00	7.00	0.80	0.00	2.00
0	34.70	5000.00	6.00	5.00	3.00	0.00	0.00	7.00	0.80	0.00	4.00
0	26.90	5000.00	6.00	5.00	3.00	0.00	1.00	7.00	0.80	0.00	1.00
0	25.20	5000.00	6.00	5.00	3.00	0.00	1.00	7.00	0.80	0.00	6.00
1	6.90	5000.00	6.00	5.00	3.00	0.00	0.00	6.00	0.80	0.00	3.00
1	10.50	5000.00	6.00	5.00	3.00	0.00	0.00	6.00	0.80	0.00	2.00
1	9.20	5000.00	6.00	5.00	3.00	0.00	0.00	6.00	0.80	0.00	1.00
1	9.10	5000.00	6.00	5.00	3.00	0.00	0.00	6.00	0.80	0.00	4.00
0	15.60	5000.00	6.00	5.00	3.00	0.00	0.00	6.00	0.80	0.00	6.00
0	15.70	5000.00	6.00	5.00	3.00	0.00	0.00	6.00	0.80	0.00	3.00
0	9.20	5000.00	6.00	5.00	3.00	0.00	0.00	6.00	0.80	0.00	2.00
1	9.30	5000.00	6.00	5.00	3.00	0.00	0.00	6.00	0.80	0.00	1.00
0	10.90	5000.00	6.00	4.00	2.00	0.00	0.00	5.00	0.81	0.00	1.00
0	15.80	5000.00	6.00	4.00	2.00	0.00	0.00	5.00	0.81	0.00	3.00
1	6.20	5000.00	6.00	4.00	2.00	0.00	0.00	5.00	0.81	0.00	3.00
1	8.60	5000.00	6.00	4.00	2.00	0.00	0.00	5.00	0.81	0.00	1.00
1	4.70	5000.00	6.00	4.00	2.00	0.00	0.00	5.00	0.81	0.00	3.00
1	10.90	5000.00	6.00	4.00	2.00	0.00	0.00	5.00	0.81	0.00	2.00
1	9.20	5000.00	6.00	4.00	2.00	0.00	0.00	5.00	0.81	0.00	4.00

HC130 16 OCT 79 82'/95'CUTTERS

1	5.60	2000.00	15.00	6.00	0.00	0.00	0.00	5.00	0.54	0.00	5.00
1	6.80	2000.00	15.00	6.00	0.00	0.00	1.00	5.00	0.54	0.00	5.00
1	12.70	2000.00	15.00	6.00	0.00	0.00	0.00	4.00	0.54	0.00	5.00
1	18.60	2000.00	15.00	6.00	0.00	0.00	0.00	4.00	0.54	0.00	5.00
1	25.20	2000.00	15.00	6.00	0.00	0.00	0.00	5.00	0.54	0.00	5.00
1	31.20	2000.00	15.00	6.00	0.00	0.00	0.00	5.00	0.54	0.00	5.00
1	5.50	5000.00	15.00	9.00	1.00	0.00	1.00	5.00	0.57	0.00	5.00
1	6.80	5000.00	15.00	9.00	1.00	0.00	0.00	5.00	0.57	0.00	5.00
1	12.80	5000.00	15.00	9.00	1.00	0.00	0.00	5.00	0.57	0.00	5.00
1	18.70	5000.00	15.00	9.00	1.00	0.00	0.00	5.00	0.57	0.00	5.00
1	25.60	5000.00	15.00	9.00	1.00	0.00	0.00	6.00	0.57	0.00	5.00
1	31.50	5000.00	15.00	9.00	1.00	0.00	0.00	6.00	0.57	0.00	5.00

HC130 16 OCT 79 TARGETS:RAFTS

0	3.20	2000.00	15.00	6.00	0.00	0.00	1.00	5.00	0.54	0.00	3.00
0	4.70	2000.00	15.00	6.00	0.00	0.00	1.00	5.00	0.54	0.00	2.00
1	8.90	2000.00	15.00	6.00	0.00	0.00	1.00	5.00	0.54	0.00	3.00
0	2.90	2000.00	15.00	6.00	0.00	0.00	1.00	5.00	0.54	0.00	3.00
0	9.20	2000.00	15.00	6.00	0.00	0.00	1.00	5.00	0.54	0.00	3.00
0	7.40	2000.00	15.00	6.00	0.00	0.00	1.00	5.00	0.54	0.00	2.00
0	3.70	2000.00	15.00	6.00	0.00	0.00	1.00	5.00	0.54	0.00	3.00
1	13.40	2000.00	15.00	6.00	0.00	0.00	0.00	4.00	0.54	0.00	2.00
0	21.40	2000.00	15.00	6.00	0.00	0.00	0.00	4.00	0.54	0.00	3.00
0	19.40	2000.00	15.00	6.00	0.00	0.00	0.00	4.00	0.54	0.00	2.00
0	26.50	2000.00	15.00	6.00	0.00	0.00	0.00	5.00	0.54	0.00	2.00
0	32.40	2000.00	15.00	6.00	0.00	0.00	0.00	5.00	0.54	0.00	2.00
1	3.50	3000.00	15.00	9.00	1.00	0.00	0.00	5.00	0.57	0.00	3.00
0	2.20	3000.00	15.00	9.00	1.00	0.00	1.00	5.00	0.57	0.00	2.00
1	2.20	3000.00	15.00	9.00	1.00	0.00	1.00	5.00	0.57	0.00	3.00
1	8.20	3000.00	15.00	9.00	1.00	0.00	0.00	5.00	0.57	0.00	2.00
0	10.00	3000.00	15.00	9.00	1.00	0.00	1.00	5.00	0.57	0.00	3.00
0	34.40	3000.00	15.00	9.00	1.00	0.00	0.00	6.00	0.57	0.00	3.00
0	32.80	3000.00	15.00	9.00	1.00	0.00	0.00	6.00	0.57	0.00	2.00
0	28.60	3000.00	15.00	9.00	1.00	0.00	0.00	6.00	0.57	0.00	3.00

HC130 17 OCT 79 TARGETS:41'/44'BOATS

1	6.60	1000.00	13.00	14.00	2.00	0.00	1.00	1.00	0.82	0.00	2.00
1	5.80	1000.00	13.00	14.00	2.00	0.00	1.00	1.00	0.82	0.00	2.00
1	4.90	1000.00	13.00	14.00	2.00	0.00	1.00	1.00	0.82	0.00	2.00
1	14.70	2000.00	14.00	16.00	3.00	0.00	0.00	3.00	0.82	0.00	2.00
1	8.50	2000.00	14.00	17.00	3.00	0.00	0.00	2.00	0.82	0.00	2.00
1	14.40	2000.00	14.00	17.00	3.00	0.00	0.00	2.00	0.82	0.00	2.00
1	21.40	2000.00	14.00	17.00	3.00	0.00	0.00	3.00	0.82	0.00	2.00
1	27.60	2000.00	14.00	17.00	3.00	0.00	0.00	4.00	0.82	0.00	2.00
1	3.80	3100.00	14.00	15.00	3.00	0.00	1.00	2.00	0.78	0.00	2.00
1	1.50	3000.00	14.00	15.00	3.00	0.00	0.00	3.00	0.78	0.00	2.00
1	6.60	3000.00	14.00	15.00	3.00	0.00	0.00	3.00	0.78	0.00	2.00
1	12.00	3000.00	14.00	15.00	3.00	0.00	0.00	3.00	0.78	0.00	2.00
1	17.00	3000.00	14.00	15.00	3.00	0.00	0.00	4.00	0.78	0.00	2.00
1	23.40	3000.00	14.00	15.00	3.00	0.00	0.00	5.00	0.78	0.00	2.00
1	28.80	3000.00	14.00	15.00	3.00	0.00	0.00	5.00	0.78	0.00	2.00

HC130 17 OCT 79 TARGETS: 16'BOATS

0	15.70	2000.00	14.00	16.00	3.00	0.00	1.00	3.00	0.82	0.00	10.00
0	9.70	2000.00	14.00	16.00	3.00	0.00	1.00	2.00	0.82	0.00	10.00
0	8.80	2000.00	14.00	16.00	3.00	0.00	1.00	2.00	0.82	0.00	6.00
0	2.60	2000.00	14.00	17.00	3.00	0.00	1.00	2.00	0.82	0.00	10.00
0	8.40	2000.00	14.00	17.00	3.00	0.00	0.00	2.00	0.82	0.00	10.00
0	9.20	2000.00	14.00	17.00	3.00	0.00	0.00	2.00	0.82	0.00	6.00
0	15.30	2000.00	14.00	17.00	3.00	0.00	0.00	3.00	0.82	0.00	10.00
0	16.20	2000.00	14.00	17.00	3.00	0.00	0.00	3.00	0.82	0.00	6.00
0	20.50	2000.00	14.00	17.00	3.00	0.00	0.00	4.00	0.82	0.00	10.00
0	21.90	2000.00	14.00	17.00	3.00	0.00	0.00	4.00	0.82	0.00	6.00
0	15.00	3000.00	14.00	15.00	3.00	0.00	0.00	2.00	0.78	0.00	10.00
1	14.80	3000.00	14.00	15.00	3.00	0.00	1.00	2.00	0.78	0.00	6.00
0	9.20	3000.00	14.00	15.00	3.00	0.00	1.00	3.00	0.78	0.00	10.00
0	3.60	3000.00	14.00	15.00	3.00	0.00	1.00	3.00	0.78	0.00	6.00
0	2.80	3000.00	14.00	15.00	3.00	0.00	1.00	3.00	0.78	0.00	10.00
0	9.00	3000.00	14.00	15.00	3.00	0.00	1.00	4.00	0.78	0.00	10.00
0	9.50	3000.00	14.00	15.00	3.00	0.00	1.00	4.00	0.78	0.00	6.00
0	15.60	3000.00	14.00	15.00	3.00	0.00	1.00	5.00	0.78	0.00	10.00
0	16.40	3000.00	14.00	15.00	3.00	0.00	1.00	5.00	0.78	0.00	6.00
0	21.70	3000.00	14.00	15.00	3.00	0.00	0.00	5.00	0.78	0.00	10.00
0	22.60	3000.00	14.00	15.00	3.00	0.00	0.00	5.00	0.78	0.00	6.00

HC150 17 OCT 79 TARGETS:RAFTS

0	5.80	1000.00	15.00	14.00	2.00	0.00	0.00	1.00	0.82	0.00	2.00
0	3.20	1000.00	15.00	14.00	2.00	0.00	1.00	1.00	0.82	0.00	2.00
0	7.80	1000.00	15.00	14.00	2.00	0.00	0.00	1.00	0.82	0.00	2.00
0	0.70	1000.00	15.00	14.00	2.00	0.00	1.00	1.00	0.82	0.00	2.00
0	1.50	2000.00	15.00	16.00	3.00	0.00	1.00	3.00	0.82	0.00	2.00
0	9.70	2000.00	15.00	16.00	3.00	0.00	1.00	3.00	0.82	0.00	2.00
1	4.70	2000.00	15.00	16.00	3.00	0.00	1.00	2.00	0.82	0.00	2.00
0	3.70	2000.00	15.00	16.00	3.00	0.00	1.00	2.00	0.82	0.00	2.00
0	10.80	2000.00	15.00	16.00	3.00	0.00	0.00	2.00	0.82	0.00	2.00
0	2.50	2000.00	15.00	16.00	3.00	0.00	1.00	2.00	0.82	0.00	2.00
0	16.80	2000.00	15.00	16.00	3.00	0.00	0.00	2.00	0.82	0.00	2.00
0	22.70	2000.00	14.00	17.00	3.00	0.00	0.00	2.00	0.82	0.00	2.00
0	29.60	2000.00	14.00	17.00	3.00	0.00	0.00	3.00	0.82	0.00	2.00
0	35.40	2000.00	14.00	17.00	3.00	0.00	0.00	4.00	0.82	0.00	2.00
0	0.90	3000.00	14.00	15.00	3.00	0.00	1.00	2.00	0.78	0.00	2.00
0	7.50	3000.00	14.00	15.00	3.00	0.00	1.00	3.00	0.78	0.00	2.00
0	1.50	3000.00	14.00	15.00	3.00	0.00	1.00	3.00	0.78	0.00	2.00
0	17.00	3000.00	14.00	15.00	3.00	0.00	0.00	3.00	0.78	0.00	2.00
0	10.60	3000.00	14.00	15.00	3.00	0.00	0.00	3.00	0.78	0.00	2.00
0	23.00	3000.00	14.00	15.00	3.00	0.00	0.00	3.00	0.78	0.00	2.00
0	29.90	3000.00	14.00	15.00	3.00	0.00	0.00	4.00	0.78	0.00	2.00
0	36.00	3000.00	14.00	15.00	3.00	0.00	0.00	3.00	0.78	0.00	2.00

HC130 16 OCT 79 TARGETS:82'795'CUTTERS

1	10.50	2000.00	8.00	5.00	0.00	0.00	0.00	2.00	0.85	0.00	5.00
1	9.40	2000.00	8.00	5.00	0.00	0.00	0.00	2.00	0.85	0.00	4.00
1	3.00	2000.00	8.00	5.00	0.00	0.00	0.00	3.00	0.85	0.00	5.00
1	2.30	2000.00	8.00	5.00	0.00	0.00	1.00	3.00	0.85	0.00	4.00
1	4.10	2000.00	8.00	5.00	0.00	0.00	0.00	3.00	0.85	0.00	5.00
1	6.40	2000.00	8.00	5.00	0.00	0.00	0.00	3.00	0.85	0.00	4.00
1	12.20	2000.00	8.00	5.00	0.00	0.00	0.00	3.00	0.85	0.00	5.00
1	12.50	2000.00	8.00	5.00	0.00	0.00	0.00	3.00	0.85	0.00	4.00
1	18.60	2000.00	8.00	5.00	0.00	0.00	0.00	3.00	0.85	0.00	5.00
1	18.50	2000.00	8.00	5.00	0.00	0.00	0.00	3.00	0.85	0.00	4.00
1	26.90	2000.00	8.00	5.00	0.00	0.00	0.00	3.00	0.85	0.00	5.00
1	25.20	2000.00	8.00	5.00	0.00	0.00	0.00	3.00	0.85	0.00	4.00
1	32.80	2000.00	8.00	5.00	0.00	0.00	0.00	4.00	0.94	0.00	5.00
1	31.40	2000.00	8.00	5.00	0.00	0.00	0.00	4.00	0.94	0.00	4.00
1	3.10	3000.00	8.00	5.00	0.00	0.00	0.00	4.00	0.88	0.00	5.00
1	1.40	3000.00	8.00	5.00	0.00	0.00	0.00	4.00	0.88	0.00	4.00
1	2.80	3000.00	8.00	5.00	0.00	0.00	0.00	4.00	0.88	0.00	5.00
1	4.90	3000.00	8.00	5.00	0.00	0.00	0.00	4.00	0.88	0.00	4.00
1	9.60	3000.00	8.00	5.00	0.00	0.00	0.00	4.00	0.88	0.00	5.00
1	10.70	3000.00	8.00	5.00	0.00	0.00	0.00	4.00	0.88	0.00	4.00
1	16.90	3000.00	8.00	5.00	0.00	0.00	0.00	5.00	0.91	0.00	5.00

1	16.50	3000.00	8.00	5.00	0.00	0.00	0.00	5.00	0.91	0.00	4.00
1	23.50	3000.00	8.00	5.00	0.00	0.00	0.00	5.00	0.91	0.00	5.00
1	20.90	3000.00	8.00	5.00	0.00	0.00	0.00	5.00	0.91	0.00	4.00
1	25.80	3000.00	8.00	5.00	0.00	0.00	0.00	5.00	0.91	0.00	4.00
1	35.00	3000.00	8.00	5.00	0.00	0.00	0.00	5.00	0.91	0.00	5.00
1	31.70	3000.00	8.00	5.00	0.00	0.00	0.00	5.00	0.91	0.00	4.00
1	4.50	3000.00	8.00	5.00	0.00	0.00	0.00	4.00	0.88	0.00	5.00
1	1.40	3000.00	8.00	5.00	0.00	0.00	0.00	4.00	0.88	0.00	4.00
1	5.10	3000.00	8.00	5.00	0.00	0.00	0.00	4.00	0.88	0.00	5.00
1	4.10	3000.00	8.00	5.00	0.00	0.00	0.00	4.00	0.88	0.00	4.00
1	9.80	3000.00	8.00	5.00	0.00	0.00	0.00	4.00	0.88	0.00	5.00
1	14.70	3000.00	8.00	5.00	0.00	0.00	0.00	4.00	0.88	0.00	4.00
1	13.60	3000.00	8.00	5.00	0.00	0.00	0.00	4.00	0.88	0.00	5.00
1	14.30	3000.00	8.00	5.00	0.00	0.00	0.00	4.00	0.88	0.00	4.00
1	1.40	3000.00	8.00	5.00	0.00	0.00	0.00	4.00	0.88	0.00	4.00
1	1.30	3000.00	8.00	5.00	0.00	0.00	0.00	4.00	0.91	0.00	5.00
1	7.30	3000.00	8.00	5.00	0.00	0.00	0.00	4.00	0.91	0.00	5.00
1	15.30	3000.00	8.00	5.00	0.00	0.00	0.00	4.00	0.91	0.00	4.00
1	13.80	3000.00	8.00	5.00	0.00	0.00	0.00	4.00	0.91	0.00	5.00
1	9.00	3000.00	8.00	5.00	0.00	0.00	0.00	4.00	0.91	0.00	4.00

AD-A085 182 ANALYSIS AND TECHNOLOGY INC NORTH STONINGTON CT F/G 17/9
ANALYSIS OF SIDE-LOOKING AIRBORNE RADAR PERFORMANCE IN THE DETE--ETC(U)
MAR 80 N C EDWARDS, T J MAZOUR, G L HOVER DOT-CG-81-79-2038
UNCLASSIFIED USCG-D-31-80 NL

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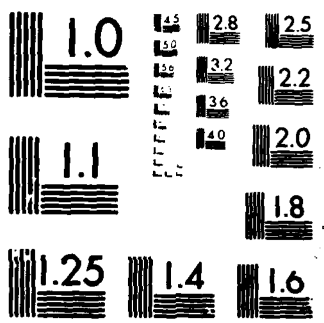

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

MC130 18 OCT 79 TARGETS:41'/44'BOATS

1	2.00	2000.00	8.00	5.00	0.00	0.00	0.00	3.00	0.85	0.00	3.00
1	3.60	2000.00	8.00	5.00	0.00	0.00	0.00	3.00	0.85	0.00	3.00
1	8.50	2000.00	8.00	5.00	0.00	0.00	0.00	3.00	0.85	0.00	3.00
1	13.80	2000.00	8.00	5.00	0.00	0.00	0.00	3.00	0.85	0.00	3.00
1	20.80	2000.00	8.00	5.00	0.00	0.00	0.00	3.00	0.85	0.00	3.00
1	26.80	2000.00	8.00	5.00	0.00	0.00	0.00	4.00	0.94	0.00	3.00
1	2.60	3000.00	8.00	5.00	0.00	0.00	0.00	4.00	0.88	0.00	3.00
1	2.40	3000.00	8.00	5.00	0.00	0.00	0.00	4.00	0.88	0.00	3.00
1	7.20	3000.00	8.00	5.00	0.00	0.00	0.00	4.00	0.88	0.00	3.00
1	12.20	3000.00	8.00	5.00	0.00	0.00	0.00	5.00	0.91	0.00	3.00
1	17.00	3000.00	8.00	5.00	0.00	0.00	0.00	5.00	0.91	0.00	3.00
1	22.80	3000.00	8.00	5.00	0.00	0.00	0.00	5.00	0.91	0.00	3.00
1	27.70	3000.00	8.00	5.00	0.00	0.00	0.00	5.00	0.91	0.00	3.00
1	1.80	3000.00	8.00	5.00	0.00	0.00	0.00	4.00	0.88	0.00	3.00
1	7.80	3000.00	8.00	5.00	0.00	0.00	0.00	4.00	0.88	0.00	3.00
1	14.60	3000.00	8.00	5.00	0.00	0.00	0.00	4.00	0.88	0.00	3.00
1	4.90	3000.00	8.00	5.00	0.00	0.00	0.00	4.00	0.91	0.00	3.00
1	11.80	3000.00	8.00	5.00	0.00	0.00	0.00	4.00	0.91	0.00	3.00
1	11.80	3000.00	8.00	5.00	0.00	0.00	0.00	4.00	0.91	0.00	3.00

HC130 18 OCT 79 TARGETS: 16'BOAT

1	9.00	2000.00	8.00	5.00	0.00	0.00	0.00	3.00	0.85	0.00	6.00
0	9.20	2000.00	8.00	5.00	0.00	0.00	0.00	3.00	0.85	0.00	6.00
0	15.90	2000.00	8.00	5.00	0.00	0.00	0.00	3.00	0.85	0.00	6.00
0	22.30	2000.00	8.00	5.00	0.00	0.00	0.00	4.00	0.94	0.00	6.00
1	8.40	3000.00	8.00	5.00	0.00	0.00	0.00	4.00	0.88	0.00	6.00
1	9.80	3000.00	8.00	5.00	0.00	0.00	0.00	5.00	0.91	0.00	6.00
0	23.00	3000.00	8.00	5.00	0.00	0.00	0.00	5.00	0.91	0.00	6.00

HC130 18 OCT 79 TARGETS:RAFTS

1	8.80	2000.00	8.00	5.00	0.00	0.00	0.00	2.00	0.85	0.00	3.00
1	9.60	2000.00	8.00	5.00	0.00	0.00	0.00	3.00	0.85	0.00	3.00
0	15.50	2000.00	8.00	5.00	0.00	0.00	0.00	3.00	0.85	0.00	3.00
0	22.30	2000.00	8.00	5.00	0.00	0.00	0.00	3.00	0.85	0.00	3.00
0	28.40	2000.00	8.00	5.00	0.00	0.00	0.00	4.00	0.94	0.00	3.00
1	32.80	2000.00	8.00	5.00	0.00	0.00	0.00	4.00	1.00	0.00	1.00
1	8.20	3000.00	8.00	5.00	0.00	0.00	0.00	4.00	0.88	0.00	3.00
1	2.20	3000.00	8.00	5.00	0.00	0.00	0.00	4.00	0.88	0.00	3.00
1	5.60	3000.00	8.00	5.00	0.00	0.00	0.00	4.00	0.88	0.00	1.00
1	2.50	3000.00	8.00	5.00	0.00	0.00	0.00	4.00	0.88	0.00	1.00
1	3.90	3000.00	8.00	5.00	0.00	0.00	0.00	4.00	0.91	0.00	3.00
1	11.40	3000.00	8.00	5.00	0.00	0.00	0.00	4.00	0.91	0.00	1.00
1	10.00	3000.00	8.00	5.00	0.00	0.00	0.00	5.00	0.91	0.00	3.00
1	17.60	3000.00	8.00	5.00	0.00	0.00	0.00	5.00	0.91	0.00	1.00
0	15.20	3000.00	8.00	5.00	0.00	0.00	0.00	5.00	0.91	0.00	1.00
1	15.70	3000.00	8.00	5.00	0.00	0.00	0.00	5.00	0.91	0.00	3.00
0	20.80	3000.00	8.00	5.00	0.00	0.00	0.00	5.00	0.91	0.00	1.00
0	27.70	3000.00	8.00	5.00	0.00	0.00	0.00	5.00	0.91	0.00	1.00
0	28.70	3000.00	8.00	5.00	0.00	0.00	0.00	5.00	0.91	0.00	3.00
0	34.00	3000.00	8.00	5.00	0.00	0.00	0.00	5.00	0.91	0.00	1.00
1	8.20	3000.00	8.00	5.00	0.00	0.00	0.00	4.00	0.88	0.00	3.00
1	1.50	3000.00	8.00	5.00	0.00	0.00	0.00	4.00	0.88	0.00	3.00
0	7.20	3000.00	8.00	5.00	0.00	0.00	0.00	4.00	0.88	0.00	2.00
1	8.00	3000.00	8.00	5.00	0.00	0.00	0.00	4.00	0.88	0.00	3.00
1	15.70	3000.00	8.00	5.00	0.00	0.00	0.00	4.00	0.88	0.00	1.00
1	6.10	3000.00	8.00	5.00	0.00	0.00	0.00	4.00	0.88	0.00	1.00
1	15.50	3000.00	8.00	5.00	0.00	0.00	0.00	4.00	0.91	0.00	1.00
1	12.20	3000.00	8.00	5.00	0.00	0.00	0.00	4.00	0.91	0.00	1.00

APPENDIX B
METRIC CONVERSION FACTORS

1. Feet to Meters

1 foot = 0.3048 meters

Thus:

3 to 4 feet swells ≈ 1 meter swells,
a 16-foot boat ≈ a 5-meter boat, and
an altitude of 500 feet ≈ a 150 meter altitude.

2. Nautical Miles to Kilometers

1 nautical mile (nm) = 1.852 kilometers (Km)

Thus:

10 nm visibility ≈ 18.5 Km visibility, and
a 2 nm range ≈ 3.7 Km range.

3. Knots to Meters/second and Kilometers per Hour

1 knot = 0.5144 meters per second
1 knot = 1.852 Kilometers per hour

Thus:

a 10-knot wind speed ≈ 5 meter per second wind speed,
and a 10-knot search speed ≈ 18 kilometer per hour search speed.